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# Studies on Nonassociative Factors Inherent in Conditioning

J. DONALD HARRIS

*University of Rochester*

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# STUDIES ON NONASSOCIATIVE FACTORS INHERENT IN CONDITIONING[1, 2]

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### *University of Rochester*

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## I. INTRODUCTION

Since the very earliest experiments on the subject it has been recognized that other factors than the principle of association by contiguity act to influence the conditioned response. In spite of the oversimplification of the process of conditioning as some authors have envisaged it, the appearance, form, and extent of the conditioned response are all demonstrably influenced by a wide variety of

factors besides the temporal relationship between stimuli seemingly essential to conditioning. Pavlov himself well recognized this fact and made extensive studies on many of these variables, such as intensity of stimuli, generalization, adaptation and many other types of inhibition, drugs, the processes of induction, and so on. To this list must be added—largely from more recent experiments—the concepts of effector fatigue, sensory adaptation, habituation, summation, facilitation, Bahnung, pseudo-conditioning, and many attitudinal, emotional, and motivational factors.

When we come to examine the relationship to conditioning of each of the variety of nonassociative factors mentioned above, we see that some of them may or may not be present in a conditioning situation, as chance or the experimenter wills. Drugs, for instance, may or may not play a part in a particular conditioning situation. Temporary motor sets with respect to chance extraneous stimuli, likewise may or may not appear to influence the strength of a particular conditioned response. Again, human conditioning is complicated by evanescent attitudes of all sorts arising to becloud the data. It may be said that any nonassociative factor is in one sense incidental to conditioning if it may be eliminated without affecting the conditioning process. We may thus define one group of nonassociative factors as "incidental" to conditioning.

On the other hand, an inspection of other nonassociative factors seems to reveal a number which may never be dispensed with, so intimately are they connected with the presentation of the stimuli actually used in conditioning. It is difficult, for example, to conceive of presenting any stimulus without initiating a factor of sensory generalization. It would likewise be impossible to present a series of electric shocks to an animal without changing that animal's modes of reactions to other stimuli, quite irrespective of the fact that a so-called conditioned stimulus may have preceded each shock. Again, if two stimuli were presented at such intervals that mutual facilitation occurred, and if, further, those intervals happened to be favorable to conditioning, it would indeed be surprising if subsequent conditioned responses were not materially affected by facilitation. Other examples could be cited. It seems fair to say that any nonassociative factor, arising in a conditioning situation as the result solely of the particular stimuli or temporal pattern employed, is in a real sense "inherent" in that situation. Accordingly we distinguish a second group of nonassociative factors inherent in conditioning.

It was the purpose of the present series of experiments to analyze the role played in avoidance conditioning of rats by three nonassociative factors inherent in that conditioning situation. In addition, it was hoped that by taking account of the contribution of nonassociative factors, the factor of association itself might emerge in somewhat clearer light.

The three factors dealt with here are habituation, pseudo-conditioning, and facilitation. Habituation arises to influence magnitude of conditioned responses through the continued presentation of the conditioned stimulus; pseudo-conditioning arises as a consequence of repeated presentation of the unconditioned stimulus; and facilitation, referring to the augmentation of one reflex as a result

of the elicitation, within certain temporal intervals, of a second reflex, arises as a consequence of the close temporal proximity of the unconditioned reflex to the conditioned response.

The design of the present experiments was intended to permit these three factors to appear in appreciable degree in a typical conditioning situation.   Rats were given training consisting of two seconds of sound followed by momentary shock.   Ten paired presentations were given a day, for ten days, whereupon an extinction series of ten sounds was presented.   A conditioned stimulus (sound) was chosen to which rats exhibit innate reaction, so that habituation would be expected to appear; a rather strong unconditioned stimulus (shock) was selected so that the probability of pseudo-conditioning would be enhanced; and the temporal interval between stimuli was so chosen that facilitation was at least a possibility.

Conditioning as the term is used here refers to the tendency, as the result of a particular type of training, for a stimulus to be followed by a response; and strength of conditioning is said to be a measure of the amount of this tendency.

The difference between strength of conditioning and strength of response must be made at the outset.   The strength of a response is determined simply by noting its static aspects—amplitude, latency, etc., and is subject to modification by any of a number of influences.   It will now be apparent that the foregoing discussion of the effect of nonassociative factors applies only to strength of response and not to strength of conditioning, since the latter is subject presumably only to time or to changes in the conditioning procedure.

Yet it is to be carefully noted that the only index we have of strength of conditioning is some aspect or other of response.   Therefore, measures of response strength are an index of strength of conditioning only when those measures of response strength are unencumbered by nonassociative factors.

The present experiments make the assumption that when all nonassociative factors are held constant in a conditioning situation, the increase in strength of the conditioned response follows a course similar to the increase in strength of conditioning.   The further assumptions are made that when two or more factors—associative or nonassociative—are present at the moment of elicitation of a conditioned response, any such factors interact as simple functions and by algebraic summation.

In other words, we assume that a particular strength of conditioning will give rise to a corresponding strength of response, but that this strength of response may be augmented or decreased in a simple manner by nonassociative factors.

## II. HISTORICAL RESUMÉ

### A. Habituation

The concept of negative adaptation, or habituation as a recent review (Harris, 22) felt to be the preferable term, has a long history in conditioning theory.   To Pavlov, who used the term "intrinsic inhibition" to apply to the decremental effect of mere repetition of a response, habituation was a very real phenomenon,

both in conditioning and extinction. Now in conditioning and extinction there are at least four distinct situations where a response occasioned by the CS[3] may undergo habituation: 1. the UCR-to-CS when that CS is presented prior to any reinforcement; 2. the UCR-to-CS when that CS is presented together with a reinforcing UCS; 3. the CR during the period of reinforced practice (conditioning proper); and 4. the CR when the CS is presented alone after a number of reinforcements (experimental extinction).

It is often said that Pavlov considered all these cases as instances of one and the same phenomenon—as he says (47, p. 44), " . . . inhibition of conditioned reflexes does not differ in the least from the corresponding inhibition of unconditioned reflexes . . . ." However, a careful reading of his papers reveals that Pavlov was well aware of differences at least in certain cases. For instance, he does not explain in terms of habituation the decrement of response to the CS if noxious stimuli are followed by food. Rather he speaks of "diversion" of impulses from one path to another. Yet the disappearance of the "investigatory" reflex both before and during conditioning were usually considered by Pavlov as alike. It was Pavlov again who first claimed that the two processes, habituation of the orientation reflex, and extinction of the CR were essentially the same type of inhibition " . . . the disappearance of the investigatory reflex . . . is in all details analogous to extinction of conditioned reflexes" (47, p. 255–256). Finally, Pavlov supposed that habituation operated during reinforcement even in the case of the newly-forming true CR. He believed that, if one first presented the CS alone a few times and subsequently began reinforcement, the habituation to such non-reinforced stimuli did not immediately come to a halt when the UCS was added, but that it actively continued, the UCS merely masking the habituatory effect. The fact that the UCS may apparently mask habituation completely does not vitiate this argument.

Pavlov, then, believed that a type of inhibition, which we have called habituation, was at work actively influencing the strength of all possible responses to the CS in the common conditioning situations.

It is fair to say that this early view represents likewise the best modern thought on the subject. A number of facts point very strongly to the conclusion that there is more involved than merely habituation in all but the simplest case, namely, the decrement of the UCR-to-CS before reinforcement, but Pavlov's general view, that in each of the other situations habituation must be recognized and dealt with, has not been disproved, rather the contrary, by any major line of evidence.

*1. Habituation of the UCR-to-CS prior to conditioning.* There seems no reasonable doubt that the disappearance of this response prior to conditioning is adequately covered solely by the concept of habituation. We have seen that Pavlov so regarded the case, especially for the later work on the investigatory

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[3] The following abbreviations will be used throughout this paper: CS, the conditioned stimulus; UCS, the unconditioned stimulus; CR, the conditioned response; UCR, the unconditioned response to the unconditioned stimulus; UCR-to-CS, the original response to the conditioned stimulus.

reflex by Rosenthal (cited by 38, p. 166).   Since that time a wide variety of conditioning experiments reports incidentally that the CS had to be presented a few times before it became "neutral".   As typical of these studies may be cited the following:

Switzer (57) found it necessary to discard all prospective subjects who winked more than twice in succession when the CS (buzzer) was sounded alone at the beginning of the experiment.   Similarly Wolfle (68) reports that some of her subjects lifted the finger from an electrode upon trials with bell alone.   Later workers on these two responses are in general agreement.   Hilgard (27) traced the course of the UCR to light, a wink response appearing in all his subjects initially.   Ten presentations of light were required with one subject before the response disappeared.   Garvey (11) performed an investigation of the matter, showing that isolated presentations of a buzzer or of a cutaneous vibrator prior to any shock reinforcement resulted in some respiratory response by any of three criteria.   When the isolated stimuli were presented a large number of times to six subjects in the absence of shock or the expectation of shock, the respiratory index he used was seen to decrease to zero, and even below.   This point will be more fully discussed in another section.

Bernstein (6) found that to his CS, a loud click, about one third of one group of fast conditioners responded in a series of four isolated presentations before conditioning.   He was recording eye winks.   In another group given ten initial sounds, the tendency in three out of four cases was for the last five sounds to produce responses of less amplitude than the first five.   Hilgard and Campbell (30) present data showing that winks to their CS were definitely present before conditioning.

Wickens (63) reported that out of 32 subjects, 11 raised the finger a time or two in response to initial sounds.   Porter (48) presents a figure showing habituatory decrement of amplitude of eye winks to a series of five lights.   Grant (12) notes that his subjects winked to light alone.   Harris (18) found 12 out of 42 subjects responded to sound alone by raising the finger, though this response almost completely disappeared with two presentations of the sound.   With rats, Munn (44) found a considerable number of light presentations was necessary in some cases before conditioning could be begun with confidence.

A great many more instances could be cited, but a long listing would be to little purpose.   Enough has been said to indicate that it is by no means rare for an experimenter to select as the CS one which evokes a response in and of itself. There is furthermore no evidence that anything more than habituation tends to destroy these to-be-conditioned responses.

*2. Habituation of the UCR-to-CS during conditioning.*   The fate of the original response to the CS has never received its due share of attention for several reasons, chief of which is probably the opinion of Pavlov (47, p. 29) that such a response constituted an "obstacle" to the establishment of a true CR.   He noted that strong stimuli make poor conditioned stimuli, and his practice was to habituate the animal to the CS before presenting any UCS.   Another reason has been the great interest attaching to the more dramatic appearance of the "new"

response, the CR. However, a few investigators have been interested in the course of the response especially as a consequence of the general theory that the learning of new patterns of activity involves the dropping out of old ones. Forerunner of the modern statements of this principle is McDougall's (42) drainage theory, which sees the energy of the CS drained off into the pathways of the UCS, with a consequent disappearance of the original responses to the CS. Other thinkers with dissimilar backgrounds but all holding that some such diversion of energy must occur are Beritoff (5), Ukhtomsky (59), Borovski (7), Razran (49), and Wendt (62), to name the more outspoken proponents. The common opinion of this group is, that as the CR elaborates to the CS, the original response to that stimulus must disappear.

When one comes to examine the facts, however, no such necessity appears. It is true that in some cases the original response to the CS disappears during conditioning only to reappear during extinction, but this is not universally true, and in any case a multiplicity of factors besides any modern counterpart of the drainage theory could be and almost certainly are involved.

One of these factors is that of reverse conditioning, or the establishment of a connection between the original response to the CS, and the UCS. Enunciated first by Beritoff (5), the concept of reverse conditioning implies that the connection in the direction

$$\begin{aligned} \text{CS} &\; \text{---} \; \text{UCR-to-CS} \\ \text{UCS} &\; \nearrow \; \text{UCR} \end{aligned}$$

will be formed, but that this connection will be manifested in behavior primarily when the connection

$$\begin{aligned} \text{CS} &\; \text{---} \; \text{UCR-to-CS} \\ \text{UCS} &\; \searrow \; \text{UCR} \end{aligned}$$

is weak, as in experimental extinction. Accordingly, much of the evidence for the view comes from studies showing a return during extinction of the UCR-to-CS (4, 7, 28, 31, 43, 61). The latter authors state, however, that the disappearance and return of the UCR-to-CS depends upon whether it is antagonistic to the newly-forming CR, which takes final common path precedence. Furthermore, when the two responses are not antagonistic, Bernstein (6) does not find that extinction of the CR restores the UCR-to-CS.

Although "reverse" conditioning supposedly is observable most readily when the CS-CR connection is weak, at times reverse conditioning may seem strong enough to overcome the dominance of the CS-CR pathway and become apparent even during conditioning as an augmentation of the UCR-to-CS. It is this type of augmentation that Hull has termed "alpha" conditioning (34, p. 431). It has been noted by Wendt (61) for one subject in particular, Hilgard (27), again for only one subject, and by Narbutovich and Podkopaev (45). It is true that a similar augmentation was shown by Bernstein in a few subjects, but an essential control, to be discussed more fully later, indicated that the phenomenon may

arise as well in the absence of conditioning. Others who have noted "alpha" conditioning have not run this control.

Finally, in several careful studies the UCR-to-CS was not observed to decrease at all during conditioning (27; 28, Subjects D and F; 41).

The above remarks should make it clear that "reverse conditioning" is supported by no overwhelming evidence, and that one does not have to accept the disappearance of the UCR-to-CS as a necessary consequence of conditioning.

But if decrease in magnitude of the UCR-to-CS is not directly a result of conditioning, to what mechanisms may we refer in discussing such decrement as does occur? Perhaps the form of the curves of loss may provide some cue. In certain cases the concept of reflex inhibition seems applicable. When Porter (48), for example, presented a light alone, the magnitude of eyelid response quickly declined to about five millimeters, but the moment he preceded the light with airpuff the response to light *immediately* dropped to a level of two to three mm. The reader will notice, however, that this order of stimulus presentation is the so-called backward order, and it may be questioned whether the finding is relevant in view of Porter's view that conditioning did not occur in that situation.

In other cases the UCR-to-CS follows a gradually declining course during typical conditioning, and here other factors than inhibition must be invoked. Thus, Wendt (61) found the UCR-to-CS falling off. It was evidently neither inhibition nor habituation, since the decline was not abrupt nor did it occur if the CS were given alone. His explanation for the phenomenon has already been mentioned.

There are a number of cases, however, where a gradually decreasing UCR-to-CS has certain characteristics of habituation. An interesting instance is that of Porter's (48). It was noted above that the UCR-to-CS declined abruptly in that case, but what is more important for the present purpose is that, when the airpuff was discontinued and the light flashed alone, the UCR to the light *did not reappear* at once as the concept of inhibition would demand, but stayed at a still lower level near zero magnitude. Hence something which looks strongly like habituation must have supplemented reflex inhibition at least in maintaining the decrement during paired stimulation.

It is fortunately not necessary exclusively to consider complex and confounding experiments. There are some data which point unequivocally to habituation as the mechanism involved in loss of the response under consideration. Long ago Ada Yerkes observed (70) that the tube-dwelling worm *Hydroides dianthus* quickly habituated to a shadow, but if the shadow were followed by a more potent stimulus—that is, the animal was given conditioning training—the original response to the shadow was reinstated. Apparently here a continuous process of habituation was definitely at work but was becoming progressively overlaid by associative factors. The clearest discussion of the Yerkes-type conditioning situation is given by Humphrey (38, p. 167 ff.)

It is possible also to discover habituation in situations where the UCR-to-CS does not become the CR as in the Yerkes situation. With Hilgard and Campbell's subjects (30) who winked to light-airpuff stimulation, the UCR to light

decreased along a course exhibiting precisely the typical negatively accelerated habituation curve, the while CRs to that light were progressively increasing. Further evidence of the habituatory nature of the decrement comes from the extinction series (see fig. 1).   After the second day of conditioning, 10 unreinforced lights were given, with the result that not only does extinction fail to reinstate the response, as Razran (50) erroneously (in the writer's opinion) contends these data show, but that the response was actually falling off farther and exactly in accord with the expectation *if habituation were involved.*

It is concluded from the above evidence that the factor of habituation may play a very real part in influencing response strength of the UCR-to-CS whether this response becomes a CR or not.
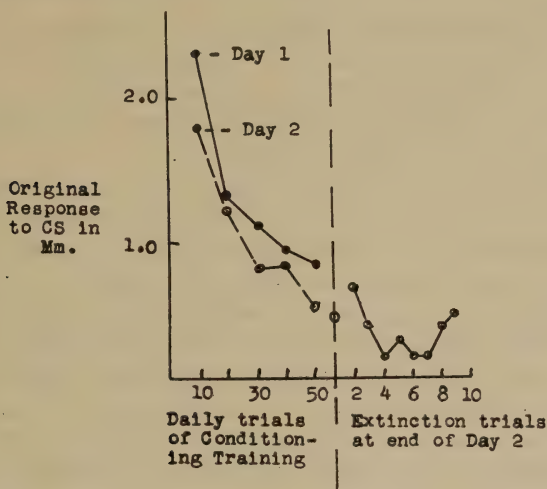


FIG. 1. COURSE OF THE ORIGINAL RESPONSE TO THE CS
Point on broken vertical line represents the average of the extinction trials, showing that habituation is continuing uninfluenced by the UCS or by its omission.
Drawn from data in table 1, p. 231, and table 2, p. 233, Hilgard and Campbell (30).

*3. Habituation of the CR during conditioning.*   It is not hard to accept the idea of habituation as influencing the course of the UCR-to-CS.   More disagreement will be found in discussing the question whether habituation is a factor during the formation of a "new" response, the CR.   It would seem at first glance to involve a logical fallacy.   How can a negative factor be operating in a response which *grows* in magnitude?   Yet we have already seen that Pavlov gave the hypothesis his support.   Indeed since Dodge (9) the existence of some negative factor in learning has been widely recognized.   In physiology the concomitant production of an inhibitory substance together with an excitatory substance has been assumed for decades (54), the modern counterpart of which, in psychology, has been elaborated most carefully by Hull (35).   Nevertheless, in spite of theoretical expectations, clear proof that any process is operating actively to retard the formation of the CR is not abundant.

One line of evidence comes from the fact, to be discussed in the next section,

that habituation is certainly one of the variables of extinction; and it seems a violation of elementary principles to assume that the process of habituation, connnected so intimately as it is with the presentation of a series of like stimuli, should *not* operate in the presence of such a series until a secondary stimulus (the UCS) is removed from the situation. It seems much more logical to assume with Pavlov that when the UCS is presented with the CS, the influence of the former masks the habituation to the latter, but that this process of habituation *is still present.* In other words, what is called the "motive" acts in such a way as to cover up habituatory processes. Besides Pavlov, many eminent thinkers including Pieron and Beritoff have subscribed to this view. More recently Garvey has stated (11) that the measure of strength of conditioning in the case of the respiratory response to sounds should be, *not* the difference between the magnitude of the CR and the relatively high pre-conditioning level, but between the magnitude of the CR and zero, since a control group, given only sounds, habituated at least to a zero level. In Garvey's experiment thus is found all the precedent necessary for speaking of habituation of the CR during actual conditioning training.

Another line of evidence comes from the facts of what Pavlov called "inhibition of reinforcement." When conditioning in one session reaches a fairly high level and the magnitude of the CR is high, if often happens that a considerable drop in that magnitude occurs if training is continued indefinitely. It is obvious that very many factors may be involved, including effector fatigue, sleep, changing internal states, etc. One factor is quite possibly habituation. When a conditioned response had become of zero magnitude even with 100% reinforcement, it was Pavlov's discovery that any of several methods could be used to reinstate the response. He lists the following (47, p. 238ff): decreasing the time of application of the CS, increasing the time between successive applications of the CS, increasing the intensity of the CS, and increasing the intensity of the UCS. It is to be noted that all this is with reference to a CR *during conditioning*, and that all the methods except the last are exactly those which have been found to reinstate an habituated response. The correspondence is more than merely suggestive.

Confirmation from this country of the general principle that CRs may fall to zero magnitude is abundant. Leaving aside those studies which subject the animal to stimulation for very long periods of time, decrement of the CR to zero with 100% reinforcement is reported to occur in relatively short time and after a relatively small number of stimulations (28, 33, 46, 51, 61, 69). An inspection of the data from these experiments leaves one with the distinct impression that habituation is a contributing factor.

Perhaps the strongest evidence for habituation of the CR during conditioning is afforded by Culler and his students (3). These workers performed the "silent extinction" of Pavlov wherein the CS is repeatedly presented after extinction is apparently complete, confirming the observation that such a procedure materially slowed at least the first subsequent reconditioning. Now on the assumption—amply documented in the next section—that habituation is very much a part of extinction, we have here presumptive evidence that, during subsequent

reconditioning, habituation does directly affect strength of CRs.    Unfortunately the extent of habituatory effect in this experiment cannot be quantified inasmuch as other factors, notably that of inverse conditioning, cannot be eliminated.

*4. Habituation of the CR during extinction.*    The elimination of the CR during experimental extinction has occasioned as much controversy as its rise during conditioning.    Certainly the phenomenon of extinction is no less complex.    Yet it will not be difficult to substantiate the claim that habituation contributes in a major way to the extinctive elimination of the CR.    Historically the concept has everything to recommend it, being proposed and sponsored by Pavlov and by Beritoff, and in more recent times most whole-heartedly by Winsor (67).    Of course even the most cursory glance at the facts, especially as regards the specificity of extinction, leaves no doubt that some more specific mechanism must be at work.    On the other hand, it seems clear that all other possible mechanisms of extinction must be supplemented by a factor of response decrement following merely upon non-reinforced elicitation.    The case has been summarized by Humphrey (38) and again very admirably by Razran (50).

In view of the well-nigh universal acceptance of habituation as one extinction variable, it will not be necessary to review the facts showing that a very great many of the phenomena to be observed in responses undergoing extinction are to be met with in strikingly similar form in responses undergoing habituation.    As examples one may cite the similar influence on extinction and habituation of strength of stimuli, and of inter-stimulus-interval and inter-series-interval; the similar relationship between degree of integration or elaboration and spontaneous recovery; the similar effect of a disinhibitory stimulus; and the almost identical range of preparations in which both extinction and habituation are found.    For specific references consult Razran (50) and Harris (22).    Confronted with these identities one is forced to agree with Humphrey (38) that it would be the part of caution to assume one common mechanism underlying both habituation and extinction—without in the least denying the possibility of additional modifications in the latter case.

## B. Pseudo-conditioning

A second major nonassociative factor in conditioning, to which Grether gave the term pseudo-conditioning, refers to the appearance or augmentation of response to a stimulus as the result of the organism's having been subjected previously to another and usually more potent stimulus.    One of the earliest workers who thought along these lines was Beritoff.    Using a bell-shock technique Beritoff (5) demonstrated that giving a dog a few shocks previous to reinforcement accelerated later conditioning; he explained this result by supposing a condition of raised excitability in the cutaneous analyzer, exerting its influence on the auditory center.    The perhaps more specific concept of "dominance" was advanced by Ukhtomski (59) and Ufland (58) and applied to conditioning particularly by Ukhtomski (60).    The latter states some of the characteristics of a "dominant" center—caused by persistent afferent stimulation—to be a higher excitability than before, ability to utilize through summation previously neutral

stimuli, and the continued effect of both after stimulation has ceased. It is evident how closely the "dominance" theory is bound up with the concept of pseudo-conditioning.

The experimental facts of pseudo-conditioning are quickly and easily comprehended. Incidental observations of the effects of the UCS—not resulting from pairing the UCS and CS—have been reported from Russia, notably, that an extinguished CR may be brought back to a high level merely by presenting the UCS a number of times (47, p. 59). Liddell and his students (40) found a similar phenomenon for motor conditioning.

Shipley (55) found one out of 11 subjects in a control group responded by finger-withdrawal to light after having been given 25 shocks to the experimental finger. It should be carefully noted that this group had previously been given paired presentations of light plus a blow to the cheek. In another group to which light had never previously been presented, none of ten subjects responded after shock training. Chance factors may explain the difference, but it seems to the writer that Shipley's shock-alone training was insufficient to produce pseudo-conditioning with a truly "neutral" stimulus. It will be noticed that in the first control group the light, although never paired with the shock, yet had been paired with a tactile stimulus of some force. The light in this case is *not* truly neutral, but means "noxious stimulus coming". Shock training then might produce enough pseudo-conditioning for such a stimulus to be of some effect.

Switzer (57) reports that with the human galvanic skin reflex, light-shock training produced considerably more response to light during extinction, disinhibition, and spontaneous recovery than did shock-alone training. Some responses to light were, however, augmented. Steckle (56) discovered rather more pseudo-conditioning of the galvanic skin reflex to light in a group given only shock previous to the test series of lights. His pseudo-conditioned responses were of shorter latency than his trace CRs.

Sears noted that if goldfish were subjected to repeated shocks, subsequent light or vibration evoked responses qualitatively similar to the shock-responses (53). The difficulty of interpreting any light-shock conditioning in the goldfish is made apparent by Sears' finding.

Schlosberg (51) presents some unquantified observations to the effect that isolated shocks given during buzz-shock conditioning of rats did result in an augmentation of responses to subsequent buzzes, and furthermore that other strong stimuli did not have the specific effect of shock. However, isolated shocks were less effective than an equal number of buzz-shock paired stimuli.

One of the more striking demonstrations of pseudo-conditioning was given by Grether (17). Monkeys were subjected to ten presentations either of an explosion of flashlight powder or of a "snake blowout," both of which elicit marked "fear" responses in this animal. After the training, a previously neutral bell elicited much the same type of response, at least in the experimental situation.

Wickens (63) has demonstrated that the effects of pseudo-conditioning and of conditioning can be distinguished. One group was given sound-shock conditioning, another pseudo-conditioning training, to a finger placed on an electrode.

Upon conditioning, the hand was turned over so that the antagonistic muscle group would be instrumental in avoiding shock.   All but one of the conditioning group avoided shock, whereas only two out of 14 of the pseudo-conditioning group did so.

One cannot conclude from this result that pseudo-conditioning has little or no effect in the human subject.   Pseudo-conditioning training in the palm-down position materially affected subsequent CRs in the palm-up position.   Upon analyzing Wickens' data we find that of a naive conditioning group and one given pseudo-conditioning training previously, the latter more quickly reached a criterion of conditioning (C.R. = 3.88).   For a fuller discussion of this experiment see Harris (18).

Harlow (24) has demonstrated pseudo-conditioning in the cat, noting that the pseudo-conditioned responses were not as strong as the UCR to the UCS, yet were retained as long as four days.   In the complete report (26) it is stated that 15 out of 18 cats exhibited pseudo-conditioned responses after 10, 20, and/or 30 shocks.   The pseudo-conditioned responses were not completely specific to the experimental situation.   An important difference between them and the UCR to shock was the shorter latency of the latter.   Very similar results have been reported by Harlow (23) from the goldfish.

Observing that, in the neonate, pseudo-conditioned responses were often indistinguishable from true CRs, Wickens and Wickens (64) put forth the idea that pseudo-conditioning may be a function of some characteristic common to the pseudo-conditioned and the conditioned stimulus.   Acting on this hypothesis they presented (65) a group of rats with 35 shocks which built up each to a climax within five seconds, and one group of rats with 35 shocks each of which built up to the same intensity within one-tenth of a second.   After this pseudo-conditioning training, one-half of each group was subjected to test stimuli in the form of lights which increased within five seconds to maximum intensity, and the other half was presented with suddenly-onset lights.   The authors found that if a rat had received "gradual" shock he would later respond more to "gradual" light than to "sudden" light.   The converse was true if the rat had received "sudden" shocks.   It was noted that the "rate of change" of the stimuli was an important characteristic both of the pseudo-conditioned and of the test stimuli, and it was concluded that pseudo-conditioning partakes of the nature of Pavlovian conditioning.

A study of Grant and Dittmer (13) and its control (14) provides valuable data as evidence that pseudo-conditioning may be a factor in conditioning.   The spatial generalization gradient made so much of by Pavlov and confirmed by Bass and Hull (1) and by Grant and Dittmer has usually been thought to be a function of the cutaneous analyzer; the latter authors opened the possibility that it may be some function of the UCS.   Whatever the case in this respect, it is seen that pseudo-conditioning contributes directly to one of the major characteristics of the CR.

Grant and Hilgard (15) found that merely presenting 40 airpuffs to the cornea of human subjects increased responses to a subsequent "CS" in a manner very

similar to that obtained with typical conditioning training; but a more curious result was obtained, namely, that if the subjects merely sat for the usual length of time and received no systematic stimuli whatever, responses to subsequent "CS" still showed the same augmentation. The point will be discussed at length later on in the paper.

Pseudo-conditioning of finger-withdrawal and of the eyelid response in the human subject was studied by Grant and Meyer (16). These students varied the conditions of expectation of different groups, finding that more pseudo-conditioned responses were obtained when no warning was given of "neutral" stimuli to come.

Pseudo-conditioning of finger-withdrawal was investigated by Harris (18), who found that pseudo-conditioned responses to tone were always present following a series of 80 strong shocks to the experimental finger, and were qualitatively very similar to true CRs. However, a series of tones as in extinction produced quicker decrement in the case of the pseudo-conditioned responses.

Harlow and Bromer (25) have shown that pseudo-conditioning of muscular movements in the monkey may proceed even when the relevant cortical centers are inactivated by freezing with ethyl chloride.

The above listing of pseudo-conditioning effects in conditioning situations is reasonably complete. There is little doubt that a specific factor, relating not to association, but still dependent upon the UCS, is a variable during actual conditioning. Not only has the demonstration been made that repeated presentation of a typical UCS may be followed by novel responses to a typical CS, but the more impressive demonstration has been provided that previous experience with the UCS may actually alter the strength of the CR. We may conclude pseudo-conditioning to be no negligible factor in conditioning.

## C. Facilitation

A third inherent nonassociative factor contributing to the strength of the CR is facilitation. As used here, facilitation refers to the increment of a response as a direct consequence of an approximately simultaneous elicitation of another response. Thus defined, there are few reflexes which are not subject to facilitation; in some cases this facilitative effect is marked and long-lasting—intervals of ten seconds between standard and facilitating stimuli are not unknown. One should then be prepared to encounter instances of facilitation in conditioning experiments, where two strong responses are in close proximity.

It must be said here that while a distinction between facilitation and pseudo-conditioning is real and useful, it is often difficult to say which should apply in a particular case. Yet, in more than a few instances, the concepts of facilitation and pseudo-conditioning can be separated experimentally. Those cases of pseudo-conditioning which are manifest an hour or more after stimulation with the UCS has ceased, have obviously nothing to do with the temporally restricted concept of facilitation. Likewise, those cases of response augmentation during conditioning where the effect (albeit a nonassociative one) depends upon a particular temporal contiguity of stimuli do not partake of the nature of pseudo-conditioning. To summarize: the characteristics of facilitation in conditioning

may be distinguished from pseudo-conditioning by the temporary nature of the response increment and by its greater generality.  In addition it is true that facilitation merely intensifies whatever response may be under way to the CS, while pseudo-conditioning brings it about that the responses to the CS resemble those to the UCS.

One of the earliest indications of a facilitative process in conditioning was turned up by Wendt (61).  He noted that a short-latency bilateral response to a tap on the patellar tendon, present even before paired stimulation in one subject and appearing quickly in others, underwent an augmentation with repeated paired stimuli.  Hilgard (27) reported a similar phenomenon for one subject for the eyelid response.  It has been assumed that this augmentation depended upon conditioning-type training and is in reality a true associative phenomenon. The situation is not completely clear as yet for the knee-jerk, but for the eyelid response it now seems certain that the augmentation which Hilgard found was not dependent upon association, and may well have been a facilitatory phenomenon.  At all events, repeated attempts to confirm this "alpha" conditioning of the eyelid response have all failed to demonstrate it unequivocally (6, 15, 29, 48).  The most illuminating material for the purpose here comes from Bernstein (6).  A group to which he gave typical conditioning showed an augmented response to the CS it is true, but this augmentation did not show any particular course typical of associative phenomena—indeed, six of nine subjects showed a decrement in response during conditioning training; furthermore, three of a control group of four subjects given CS and UCS, *but in random order*, exhibited a like increment.  Bernstein's conclusion has met with general acceptance, that "the facilitation observed during the conditioning sessions is merely a special case of this general sensitizing action of the shocks."  p. 186.

It should be carefully noted that all the experiments cited so far in this section have to do with the UCR-to-CS, not with the true CR.  The writer is aware of no study beside the present one which does demonstrate unequivocally a facilitation effect on the CR.  However, there is no physiological reason why such an effect should not occur.  Conditioned responses are subject to many influences analogous to facilitation.  Such demonstrations as, that hunger contractions facilitate the knee-jerk (8) and also increase speed of conditioning (10), and the well-known fact that two just-extinguished CSs each acting on the same response will summate to produce that response, point toward such a conclusion.  The case seems to be simply that no one has as yet taken the opportunity to establish control experiments which do effectively isolate a facilitative factor in conditioning.

### III. DESCRIPTION OF THE EXPERIMENTS

#### A. Apparatus

The apparatus consisted of a restraining cage connected pneumatically with a recording tambour, an electrical device for controlling the presentation of stimuli, and a kymograph, together with appropriate signal markers.  The restraining cage consisted of a celluloid cylinder 10″ in diameter and 15″ high,

with metal top and bottom. This stabilimeter was mounted inside a sound-deadened box and swung from a $4\frac{3}{4}''$ metal bellows. This bellows was connected through 8' of copper tubing to a $2\frac{7}{8}''$ metal bellows equipped with a $6''$ recording lever of light metal hypodermic tubing connected with an inkwell. Any gross vertical movement of the stabilimeter would thus occasion a deflection of the recording lever. When a rat is placed in this apparatus and the recording lever arranged to trace on paper, movements of the order involved in scratching and grooming are recorded well and are measurable to the nearest half-millimeter.

The CS was two seconds of complex sound, provided by a small buzzer mounted inside the sound-deadened box but not touching the stabilimeter itself. The UCS was a momentary pair of shocks $\frac{1}{8}$ second apart. Each was of .1 MA intensity delivered from a constant-current circuit to the metal floor of the stabilimeter as one electrode, and to a wound clip permanently fixed to the back of the animal as the other electrode. A wire led from the top of the stabilimeter to the wound clip, kept fairly taut by a light coil spring. The arrangement gave a highly constant electrical stimulus, the apparatus failing only two or three times in thousands of trials over a period of 18 months. In those cases the wound clip became unattached while the rat was in the apparatus. So few mishaps compares extremely favorably with any other method of presenting electrical shock to a freely-moving animal. The more common method of shock delivered through bars upon which the animal remains is by comparison a crude and ineffective device.

Presentation of stimuli was controlled by means of a rotating-disc interval timer capable of great variety and of easy remote control. Only one failure of this timer occurred during an actual trial with a rat in the apparatus, at which time a temporary repair was effected in a few seconds.

The recording system was ink-writing, which in this case was of sufficient sensitivity to be satisfactory because of the fine adjustment possible between recording lever and paper. In most cases the lever never touched the paper itself, a thin film of ink intervening. Thus, loss of magnitude of recorded response did not become a problem. The taking of extended records was effected by use of a long-paper kymograph. It was possible to secure records for several rats on a single sheet of paper.

## B. Animals

The selection of the proper experimental animal was of major consequence in the present case. The rat seemed a logical choice. It was expedient that a strain as active as possible be used in order that, first, a relatively high level of response to initial stimuli would be available for habituation, and second, that habituation would not quickly become so deep that no technique except prolonged conditioning would evoke any response whatever. The ordinary strain of white rat exhibits a response which habituates to the CS of the present experiments, but it quickly becomes so lethargic than even extended periods of conditioning often produce no response at all in some rats (Munn, 44). The writer was fortunate in having access to a strain of part-wild Norwegian black

rats which he knew to be extremely active compared to the usual Wistar white stock.   Through the kindness of Drs. C. T. Morgan and K. S. Lashley a few males and a dozen females of this strain were obtained.

Upon their arrival most of the females were pregnant, so that it was impossible to use the pups—the sire not being known in any case.   Accordingly the offspring of the first generation shipped were selected as breeders for the whole series of experiments.   One male was chosen as the sire, and all but two of the other males killed.   This sire then is the male parent of all the 184 rats used. He was bred to his own litter-mates and to a few full sibs to produce the rats which were actually given experimental training.

The technique whereby litter-mate control was effected was as follows: from the sire and each breeding female a first litter was obtained, the males of which were saved and placed in the experimental groups.   Experiments A and B were run simultaneously, comprising seven groups in all.   From a particular breeding female then, a litter of seven males would be thrown one into each experimental group.   In case less than seven or more than seven males matured from this litter, some groups had none or more than one rat from that litter.   A second litter was then obtained from all breeders and the same procedure followed.   In some cases three and four litters were obtained from the same female.   The result of this procedure was that each of the experimental groups contained at least two males from a single dam.   Regardless of when litters were born, all rats were given experimental training when they were within ten days of 60 days of age. Thus it was accomplished that every rat in every group had, in every other group, two or more litter-mates or full sibs of equal or closely comparable genetic characteristics, sex, age, diet, weight, handling, and previous experience.   It was not thought necessary to transfer pups from one female to another to equate pre-weaning factors, since the rats were to live for a month or more under similar conditions after weaning and before experimentation.

All rats, including breeding females, were fed a non-supplemented unrestricted diet of standard dog chow.   Pups were weaned when approximately 21 days old, segregated by sexes at that time, and placed in cages containing six to eight pups per cage until the date of experimentation.   During this period the rats were not handled at all.   They thus came to the experiment with the barest minimum of handling.   The stimuli to which they were subjected during this period were, however, of a somewhat intense nature in the form of sounds in the animal room.

Only one difference was introduced in the case of animals used in Experiment C.   This experiment, performed after A and B were terminated, could not utilize the same breeding females since it was almost certain that the already-depleted number of breeders would die before the end of this third part of the series.   Accordingly a fresh batch of breeding females was selected from pups dropped in the third litters of the original breeders.   As sire for the rats in this group the chance was taken that the original sire would survive long enough to serve each female two or three times.   For Experiment C, therefore, rats were used in every way comparable to those of the previous experiments, but whose dams were third-litter pups of the original breeders.

## C. Procedure

General procedure was unaltered for all rats, regardless of the type of stimuli given. The animals were carried from their living quarters to a room adjoining the experimental room. When it was certain that the appropriate switches were set and the writing pens operating correctly, a single rat was taken from his living cage and carried into the experimental room. The door between the rooms was then shut so that no noise from the experimental room except the low hum of the kymograph could be heard by the rats left in their living cage. The experimental rat was then placed in the stabilimeter and the electrode suspended from the top was clipped to the wound clip fastened to the skin of the animal's back. The door of the stabilimeter was then closed, and likewise the door of the sound-deadened enclosing box. A final inspection of the switches and writing pens was made, whereupon the first of the stimuli appropriate to the particular rat was presented. Throughout the experimental period the kymograph ran continuously. At the end of the period the motors were stopped and the writing pens operated once by hand so that if by chance the pens were not in line this could be allowed for later in reading that record. The rat was then removed and another inserted.

It is emphasized again that every rat, even though his role was merely to remain in the apparatus, was accorded exactly the same treatment in so far as possible; even if no shocks were ever to be administered, for example, the electrodes were nevertheless always attached throughout training and extinction. It is on the basis of this equality of treatment, as well as on the genetic controls used, that the practical claim can be made that all factors except those arising from systematically-presented stimuli were equated from group to group.

## IV. EXPERIMENT A: HABITUATION, FACILITATION, AND PSEUDO-CONDITIONING DURING CONDITIONING AND EXTINCTION

### A. Introduction

The present experiment is concerned with the analysis of the roles played in conditioning by the factors of habituation, facilitation, and pseudo-conditioning; their demonstration in an actual conditioning situation is accordingly our first concern. We will begin by considering the specific types of training given to different groups in Experiment A:

*1. Conditioning group.* Each rat of this group was inserted in the stabilimeter and the clip electrode attached. Approximately ten seconds after the stabilimeter door and the door of the enclosing box were shut, the first conditioning trial was given. A conditioning trial consisted of a CS followed immediately by a UCS. After ten conditioning trials the rat was removed from the apparatus. Temporal intervals between trials were held constant from day to day and from rat to rat. Where each dash represents a conditioning trial and each figure the number of intervening rotations of the disc of the interval timer, the invariable sequence was:

$$- 2 - 1 - 3 - 1 - 2 - 3 - 2 - 3 - 1 -$$

The timer disc rotated once in ten seconds, so that the total time for each rat from the beginning of the first stimulus of the day to the end of the last stimulus of the day was 182 and $\frac{1}{8}$ seconds. Ten conditioning trials were thus given each day for ten days. At the conclusion of the tenth day's training, without removing the animal from the apparatus or even stopping the motors, an extinction series of ten CS alone was administered, in exactly the same temporal pattern as the CS during the conditioning training. The first extinction trial came after only one rotation of the interval timer, or seven and seven-eighths seconds after the termination of the last conditioning trial. On this day, therefore, each rat was inserted in the apparatus for 372 and $\frac{1}{8}$ seconds, plus what few seconds it required to insert and to remove him.

Approximately 24 and again 48 hours after the first extinction series, the animal was reinserted into the apparatus, the clip electrode again attached, and a second and third extinction series respectively were administered, the temporal pattern of CS remaining as before. The animals of the Conditioning Group were thereupon discarded.

2. *Apparatus-habituation group*. Each rat of this group was inserted into the stabilimeter and the clip electrode attached. The animal remained in the apparatus for 182 and $\frac{1}{8}$ seconds, plus what time it took to insert and to remove him. In other words, animals of this group received exactly the same treatment as those of the Conditioning Group, except that buzzer and shocker were disconnected. Signal markers, however, operated as if conditioning training were being given. At the conclusion of the tenth day of this exposure to the apparatus, or seven and seven-eighths seconds after the termination of the last dummy stimulus of the tenth day, an "extinction" series of 10 CS was administered exactly as with the Conditioning Group, and with exactly the same inter-stimulus-intervals. Similarly also, a second and a third "extinction" series were administered 24 and 48 hours after the first such series.

3. *CS-habituation group*. Each animal of this group received exactly the same treatment as did the Conditioning Group, except that the shock was never administered. Habituation training was given for ten days, followed by the usual three "extinction" series. It will be noted that on the tenth day the animals of this group received two series of CS, each series exactly alike.

4. *Random-order group*. Each animal of this group received a series of ten CS and ten UCS a day for ten days. The sequence used for this group was as follows, where S represents shock and B represents buzzer and the figures represent the number of rotations of the timer disc:

S2B1S3S1B2B3S2B3S1B1S2B1S3S1B2B3S2B3S1B

At the conclusion of the tenth day of such training, or eight seconds after the termination of the last stimulus, administration of the usual three "extinction" series was begun.

5. *Pseudo-conditioning group*. Each animal of this group received ten UCS a day for ten days. The temporal pattern was held exactly like that of the shocks of the Conditioning Group. At the conclusion of the tenth day's train-

ing, or nine and seven-eights seconds after the termination of the last shock, the usual "extinction" series were presented.

The general plan of the regimen presented to the several groups may quickly be comprehended. One group of animals is given conditioning training in as typical a manner as possible; all variables from rat to rat are held as constant as could be done. In addition, rats as closely similar to the first group as could be obtained were subjected to the same experimental apparatus, except that certain stimuli were withheld in some groups or presented in slightly different order in one instance. It is of importance to note that, no matter what type of training was given to individual groups, all groups were given the identical "test" series, namely, the extinction series of the Conditioning Group.

The raw data obtained are mechanically very easy to quantify. One measures with a transparent millimeter scale the extent of departure from the baseline of the tracing in question. A single reading of the maximum deflection of the recording lever is entered as the score of a rat on a particular trial. What we deal with in this experiment, then, is an index of the maximum energy exerted by the animal as the result of the presentation of a stimulus.

It is hardly necessary to defend this measure of response strength as an appropriate index of strength of conditioning. Probably incidence of response is the most common-used index of strength of conditioning—yet maximum response is after all what one measures when one records incidence of response when the response is only slight. With conditioning as with other reflex phenomena, some indication of response strength is often of the greatest value. It seems to the writer that a measure of response magnitude is a better index of strength of conditioning than some more indirect index such as number of responses—without regard to their magnitude—during a certain period of conditioning.

Beside maximum response, another available index of response magnitude would be some index of total energy involved. It could be argued that such an index would be preferable. It is doubtful, however, whether measures of energy expenditure in terms of total area between the baseline and the tracing of a particular lever excursion could be done satisfactorily. In addition to the complicated "linear oscillometer" necessary there would always be the question, in a labile response such as a rat's general activity, of where response to a stimulus began and where it terminated.

As for the reliability of the measure chosen, it is rather high. Repeated measurings of a single day's records produce almost identical totals. Strong evidence for the general reliability of the data in this situation and with this strain of rats is the fact that in most groups day-by-day plots of mean and median response of the group are often identical, and ordinarily are extremely close. It is significant that in the case of the Conditioning Group, where occasional exaggerated responses are to be expected, the mean response regularly exceeds the median somewhat. The writer concludes that the measure chosen is satisfactorily reliable, and it is felt that in the case of the Conditioning Group it is sufficiently valid as an index of strength of conditioning.

## B. Results and discussion

A consideration of the results of Experiment A will demonstrate, briefly,

1. That in this situation a rat's level of general activity suffers a decrement even when no systematic stimuli are given,

2. That when the CS is presented in the same temporal pattern as in actual conditioning but without reinforcement by the UCS, a decrement of the rat's response to the CS appears,

3. That responses to a series of ten CS are greater in the case of rats inserted for the first time on the day of the test series than with rats placed in the apparatus for approximately three minutes a day for ten days preceding, but given no systematic stimuli during this time,

4. That this difference is maintained even when the factor of apparatus-habituation is equated,

5. That when the CS is always followed by the UCS (i.e., conditioning training is given) an increment of response to the CS (i.e., the CR) occurs progressively.

6. That when the same number of CS and UCS as in conditioning are presented, but adjacent stimuli are separated by several seconds and the stimuli put in random order so that any associative factor is practically obviated, still the responses to the CS decrease less rapidly than if no UCS were given,

7. That responses to a series of ten CS as in extinction are incremented by presenting a series of ten UCS a day for ten preceding days,

8. That such "pseudo-conditioned" responses are greater in magnitude than those of the Conditioning Group during a similar extinction series, but

9. That the superiority of the Pseudo-Conditioning Group is not maintained when the factor of habituation to the CS is equated,

10. That this superiority is likewise not maintained during a second and a third extinction series given respectively 24 and 48 hours after the first such series,

11. That responses to the CS during extinction are greater for the Conditioning Group than for the Random-Order Group,

12. That this superiority is maintained during a second and a third extinction series,

13. That responses during "extinction" are greater for the Pseudo-Conditioning Group than for the Random-Order Group,

14. That this may be true even when the factor of CS-habituation is equated, and

15. That the superiority of the Pseudo-Conditioning Group over the Random-Order Group is maintained during the usual second and third "extinction" series.

The discussion of some of the more interesting questions raised by the results will follow.

*1. The factor of apparatus-habituation.* The first question raised is, what effect does the general situation, irrespective of the conditioning stimuli, have upon the rat's level of general activity. Certainly we do not expect the rat,

inquisitive little fellow that he is, to remain perfectly quiet when introduced to
a new situation.   Nor does he.   The curve of response of the Apparatus-Habitu-
ation Group shows that for a day or two the rat's response during the ten dummy
stimuli was of some considerable magnitude compared with what it later became
(see fig. 2, Curve B).

As was pointed out above, one of the chief characteristics of an habituatory
response decrement is that a plot of its course shows decided negative accelera-
tion.   Another characteristic is that generalization occurs so that after habitua-
tion to one set of stimuli has taken place, other stimuli will be responded to with
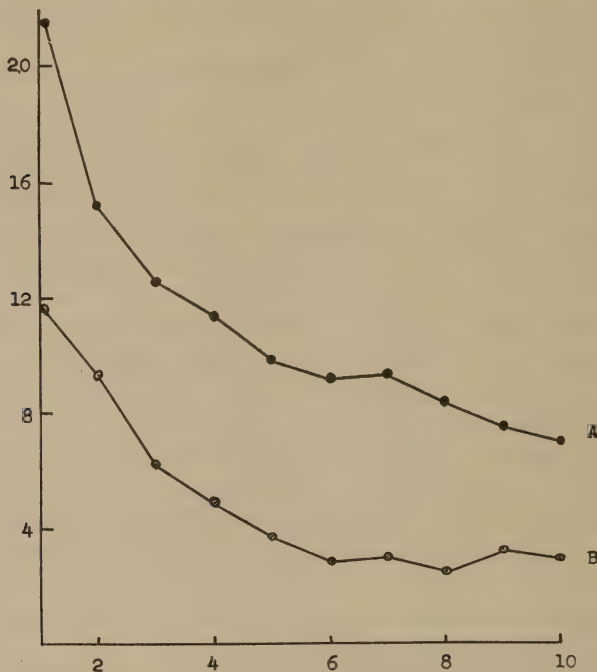


FIG. 2. EFFECT OF EXPOSURE TO THE APPARATUS ALONE AND TO THE CS
Ordinate: response strength in mean millimeters.   Abscissa: days.   A: CS-habituation
group on days 1–10.   B: apparatus-habituation group on days 1–10.

decreased magnitude.   It is easy to show that both of these characteristics ap-
pear in the responses of the Apparatus-Habituation Group, and the conclusion
is strongly supported that the response decrement from day to day of this group
is habituatory in nature.

A glance at figure 2, Curve B, reveals the negatively accelerated course of
the response in question.   The matter of generalization requires somewhat
more complicated reasoning to substantiate.   It will be recalled that the series
of ten CS given to the CS-Habituation Group on the *first* day was exactly like
that given to the Apparatus-Habituation Group as the "extinction" series on
the *tenth* day.   Here then we have two groups given the same test stimuli but
with the added factor of apparatus-habituation in the one case.   Figure 3 shows

that prolonged exposure to the apparatus had a profound effect on responses to the test series.  Table I indicates that the difference between the groups is reliable.

Only the single plausible assumption, that the reduction in response magnitudé of the Apparatus-Habituation Group is due to its previous training, is

TABLE I

*Effect of apparatus-habituation on response to the CS*

| | MEAN AMPLITUDE PER TRIAL | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 3.8 | 2.6 | 2.0 | 1.9 | 1.7 | 2.0 | 1.9 | 2.0 | 1.7 | 1.7 |
| 2 | 1.6 | 1.2 | .8 | 1.1 | .9 | .9 | .7 | .6 | .7 | .6 |
| Diff.................. | 2.2 | 1.4 | 1.2 | .8 | .8 | 1.1 | 1.2 | 1.4 | 1.0 | 1.1 |
| Sigma$_D$.............. | .46 | .37 | .31 | .37 | .28 | .34 | .34 | .40 | .26 | .37 |
| C. R.................. | 4.7 | 3.7 | 3.8 | 2.1 | 2.8 | 3.2 | 3.5 | 3.5 | 3.8 | 2.2 |

*1 = CS-habituation group on first day.  2 = Apparatus-habituation group during first "extinction."
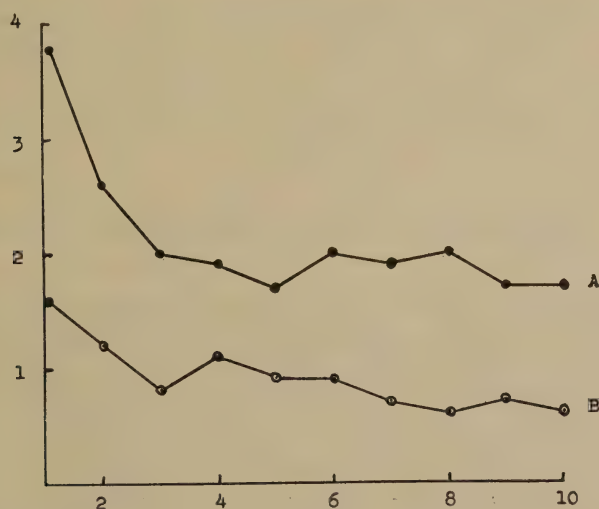


FIG. 3. EFFECT OF APPARATUS-HABITUATION ON RESPONSE TO THE CS
Ordinate: response strength in mean mm.  Abscissa: trials.  A: CS-habituation group on day 1.  B: apparatus-habituation group during first "extinction" series.

necessary in order to reason that the reduced response in the case of the Apparatus-Habituation Group is a function of generalization of habituation.

We may then conclude that the reduction in response magnitude of the Apparatus-Habituation Group is truly an habituatory phenomenon.

An interesting and illuminating example of inter-species differences upon being

subjected to experimental apparatus is afforded by a comparison of the present Apparatus-Habituation Group and one of the control groups of Grant and Hilgard's (15) experiment on light-sound eyelid conditioning in human subjects. When these authors required human subjects to submit to placement and adjustment of apparatus, and to sit quietly for a time approximately that of a group given 40 conditioning trials, what was their surprise to find that responses of the two groups to an identical "extinction" series were indistinguishable. Yet it seems that such a result should occasion no great surprise. It is probably unnecessary to consider, in this connection, purely "physiological" causes of reflex augmentation. The principle of "expectancy," which Hilgard himself has espoused in a similar situation, is quite adequate to explain the phenomenon on a relatively high level. The present experiment would indicate some such symbolic level, inasmuch as no reflex augmentation occurred in the lower animals—quite the contrary. It is claimed that our results throw considerable

TABLE II

*Theoretical course of CS-habituation*

| | MEAN AMPLITUDE PER DAY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 21.6 | 15.2 | 12.6 | 11.4 | 9.9 | 9.2 | 9.4 | 8.4 | 7.5 | 7.0 |
| 2 | 11.7 | 9.3 | 6.2 | 4.9 | 3.7 | 2.9 | 3.0 | 2.5 | 3.2 | 3.0 |
| Diff.................. | 9.9 | 5.9 | 6.4 | 6.5 | 6.2 | 6.3 | 6.4 | 5.9 | 4.3 | 4.0 |
| Sigma$_D$............. | 2.5 | 1.8 | 1.4 | 1.3 | 1.1 | 1.0 | 1.0 | .9 | 1.0 | .8 |
| C. R................. | 3.9 | 3.2 | 4.5 | 5.0 | 5.6 | 6.3 | 6.4 | 6.5 | 4.3 | 5.0 |

* 1 = CS-habituation group on days 1–10. 2 = Apparatus-habituation group on days 1–10.

light on the apparently anomalous data of Grant and Hilgard by showing that no additional factor making for reflex augmentation was demonstrated by these authors to be *inherent* in the presentation of the conditioning stimuli. The writer concludes that it is not necessary from a consideration of Grant and Hilgard's results to view askance any of the data from conditioning data from animals—or indeed much of the data from human subjects.

*2. The factor of CS-habituation.* The next factor which we may consider is that of the decrement of response to the CS of the CS-Habituation Group. Figure 2, Curve A shows the course of this response. A comparison of this response with that of the Apparatus-Habituation Group over the same ten-day period (see Table II) shows a reliable difference in favor of the former.

There is little doubt from what has been said already that the response decrement to the CS of the CS-Habituation Group is truly and purely habituatory; but it is evident that it is a combination of habituation to a general factor (i.e., the apparatus and general situation) and in addition, to a specific factor (i.e., the CS). In accordance with our assumption that all factors operating to produce the strength of a response summate simply and algebraically, it is necessary

to subtract the response magnitude attained by the Apparatus-Habituation Group from that of the CS-Habituation Group (see again Table II) to ascertain the purely theoretical nature of the course of decrement in the hypothetical case of there being no apparatus at all, only CS, in the rat's environment. We are driven to this expedient because it is not possible to habituate the animals first to the apparatus and then to present the CS, and expect to obtain the true picture of the factor of CS-habituation. Such a procedure destroys, as we have seen through the process of generalized habituation, the first exaggerated responses to a novel CS and a novel apparatus *together*.

However, in the manipulation with other variables of the factor of CS-Habituation, it is fortunately inevitable that the factor of apparatus-habituation is equated. This for the simple reason that all groups have been submitted to almost identical habituation to the apparatus; it would therefore be of no point to correct all groups alike for the identical factor and by the identical mathe-

TABLE III

*Amount by which response to the CS decreases from that on the first day of habituation*

| | MEAN AMPLITUDE PER DAY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 |
| 2 | 21.6 | 15.2 | 12.6 | 11.4 | 9.9 | 9.2 | 9.4 | 8.4 | 7.5 | 7.0 |
| Diff......... | — | 6.4 | 9.0 | 10.2 | 11.7 | 12.4 | 12.2 | 13.2 | 14.1 | 14.6 |

* 1 = Response of CS-habituation group on first day. 2 = Response of CS-habituation group on days 1–10.

matical procedure. Accordingly we may ignore the "theoretical" curve of CS-Habituation and utilize simply the results *in toto* of the CS-Habituation Group.

In its original form, however, the curve of response decrement of the CS-Habituation Group is misleading to some extent. One does not merely subtract it from other curves to remove the factor of CS-habituation. It must be carefully noted that any addition of factors is algebraic, and it is the factor of CS-habituation which largely supplies the negative—it is partly this factor, in other words, which must be overcome. A particular response strength to which the factor of CS-habituation contributes would not be *less*, but *greater*, if CS-habituation were removed. Accordingly we *add* some amount representing the amount by which CS-habituation presumably reduced this strength of response. What we actually add in any instance is the amount by which, after a comparable time, the response of the CS-Habituation Group has decreased *from initial strength* (see Table III). This is a straightforward procedure involving only our fundamental assumptions. It is deficient only that, in the nature of things, an appropriate amount to add for the *first* day or trial of CS-habituation cannot be ascertained. This objection is, however, a relatively minor one compared with the usefulness which the procedure has.

*3. Factors related to the UCS per se.* It is to be understood that the phrase

"factors related to the UCS *per se*" refers to all those effects which the presentation of the UCS exerts on responses to the CS, with the exception of that effect known as the associative factor.   In order to bring these nonassociative factors to light it is only necessary to present a group of rats with the CS in conjunction with the UCS, but with irregular and relatively remote temporal contiguity so that the factor of association *per se* is precluded.   It will be noted at once that this was exactly the treatment given the rats of the Random-Order Group.

The writer is well aware that changing the temporal position of stimuli from that in the Conditioning Group is bound to change the degree of facilitation which the UCS exerts on the CS.   The absolute magnitude of effect may then not be the same for the Random-Order Group as for the Conditioning Group, and so the former may be a spurious control for the latter.   Since, however, the course which any facilitation present takes *from day to day* would be expected to remain similar whatever the absolute magnitude, and since it is this day-to-day plot which the present experiments use, it is concluded that the Random-Order Group constitutes a valid control of the facilitation factor operating in the Conditioning Group.

The data of Experiment A do not permit us to distinguish the several effects of the UCS *per se* nor the quantitative role each plays in contributing to the response strength of the Random-Order Group; but it can be said with confidence that an effect exists as the result of having shocked the animals on a preceding day or days (so-called pseudo-conditioning), and another effect exists as the result of presenting the UCS and CS in fairly close temporal proximity (so-called facilitation).   The responses of the Random-Order Group then represent resultants of the factors of habituation, pseudo-conditioning, and facilitation.

Although we are not able thus far in the experiments to describe the factors of facilitation and pseudo-conditioning independently, we can arrive at an estimate of their *combined* effect by removing from the responses of the Random-Order Group the factor of habituation.   This process is somewhat involved, and it will be necessary to consider each step carefully in the light of our assumptions.   We start with the amount of response generated by the Random-Order Group on the first day of its training.   Figure 4, Curve A, presents the results of this group during training.   The response strength on the first day represents the case when there has been no previous CS-habituation.   Our problem is first to find out what the response strength would have been if CS-Habituation were the only factor to be reckoned with.   For this we take the amount by which the day-by-day responses of the CS-Habituation Group decrease from the first day (Table III) and subtract them from the *first day's* response of the Random-Order Group (see Table IV, Calculation A).   This procedure at first appears unnecessarily complicated, but it seems clear that the result of the calculation is an approximation of how much the factor of habituation *of itself* reduces the responses of the Random-Order Group.   We have here, therefore, an indication of what was desired, namely, a measure of what the response of the Random-Order Group would have been, considering that only CS-habituation acted to change it from its original first-day level.   If now we compare this measure
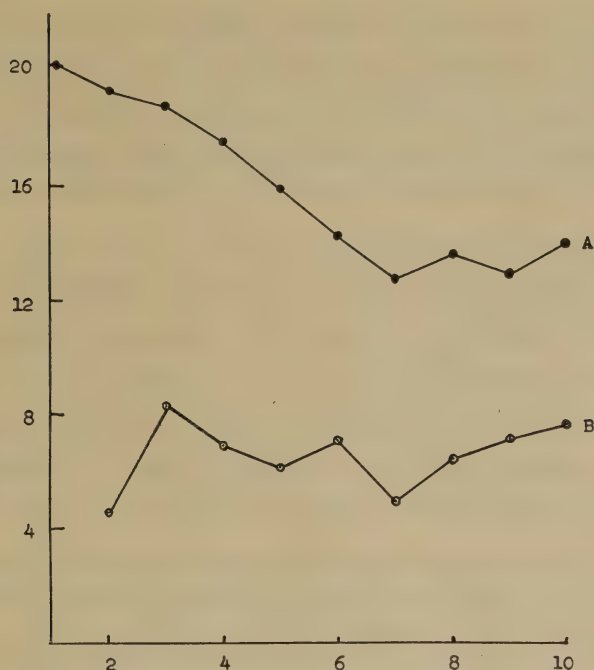
FIG. 4. EFFECT OF UCS FACTORS PER SE DURING CONDITIONING
Ordinate: response strength in mm.   Abscissa: days.   A: random-order group on days
1–10.   B: random-order group corrected for habituation.

TABLE IV

*Effect of UCS factors per se during conditioning*

| | MEAN AMPLITUDE PER DAY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Calculation A | | | | | | | | | | |
| 1* | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 |
| 2 | — | 6.4 | 9.0 | 10.2 | 11.7 | 12.4 | 12.2 | 13.2 | 14.1 | 14.6 |
| 3 | | 13.8 | 11.2 | 10.0 | 8.5 | 7.8 | 8.0 | 7.0 | 6.1 | 5.6 |
| Calculation B | | | | | | | | | | |
| 4 | 20.2 | 19.3 | 18.8 | 17.6 | 16.0 | 14.3 | 12.8 | 13.7 | 13.0 | 14.1 |
| 3 | | 13.8 | 11.2 | 10.0 | 8.5 | 7.8 | 8.0 | 7.0 | 6.1 | 5.6 |
| 5 | | 5.5 | 7.6 | 7.6 | 7.5 | 6.5 | 4.8 | 6.7 | 6.9 | 8.5 |

* 1 = Response of random-order group on first day.   2 = Amount by which habituation
presumably influenced response of random-order group.   3 = Response strength which
random-order group would presumably have shown had *only* habituation influenced it.
4 = Actual response of random-order group.   5 = Amount by which UCS factors *per se*
influence response.

with the measure of the response strength actually recovered from the group in question, we should come up with a theoretical measure of the influence of the UCS factors *per se* on the responses of the Random-Order Group. Table IV, Calculation B, depicted in figure 4, Curve B, performs this subtraction. The results of Calculation B are accordingly interpreted as representing the effect which the factors of facilitation plus pseudo-conditioning take throughout the training period.

By way of illustrating the sequence of reasoning we have used, the reader is invited to look for a moment at Table IV. The mean response of the Random-Order Group on the first day is seen to be 20.2 mm. By Day 2, however, this response would have been only 13.8 mm. if we consider only habituation, which latter has reached a strength of 6.4 by Day 2. Actually the response on Day 2 of the Random-Order Group was 19.3, and we conclude that the difference between 19.3 and 13.8, or 5.5, represents the response strength generated on Day 2 by whatever nonhabituatory factors enter the picture. Similarly with the remaining days, the nonhabituatory factors related to the UCS are given quantitative meaning.

Figure 4, Curve B, shows that when the procedure of removing the habituatory factors is carried out in the manner outlined, the combination of facilitation plus pseudo-conditioning exhibits no special trend. If either changes course markedly with respect to the X-axis, the fact is obscured by opposite changes in the other. The separation of these two factors must be deferred until we consider Experiment C.

*4. What is the nature of the response of the conditioning group?* When a group of these rats is given typical conditioning training, a day-by-day plot of the increment in response to the CS is seen to be rather unusual (see fig. 5, Curve B). It is plain that the form of this curve depends, among other things, upon the particular strain of rat and upon the intensity of the CS, and that as it stands, uncorrected for inherent nonassociative factors assuredly present, it would be entirely misleading as an indication of the growth of strength of conditioning. The assumption outlined above, that response strength bears a direct relationship to strength of conditioning, does not seem justified by one's first glance at this curve. A moment's thought, however, will recall to us the fact that the responses of the Conditioning Group are the resultant of other variables in addition to strength of conditioning. If this is true, the response of the Conditioning Group could be expected to reveal something as to the nature of the growth of strength of conditioning *only* after all other variables are removed.

Let us consider what other variables may be suspected to operate to influence the response of the Conditioning Group. First, it is clear that habituation to the experimental apparatus and situation may tend to reduce all responses with repeated exposures, the conditioned response being no exception. Second, it is certain that the repeated presentation of the CS brings about a reduced tendency for response to occur to that stimulus. Now since the CS-Habituation Group received exactly the same number of CS and in the same temporal pattern, we may at once determine the effect of apparatus and of CS-habituation in this situa-

tion. What we want is a measure of how much the factors of habituation reduced the response—since we reason that had habituation *not* been present, the response would have been *greater*. This measure we have seen to be the amount by which responses of the CS-Habituation Group decrement from that on the first day (see again Table III). It is concluded, when the amount of Table III on any day subsequent to Day 1 is added to the response of the Conditioning
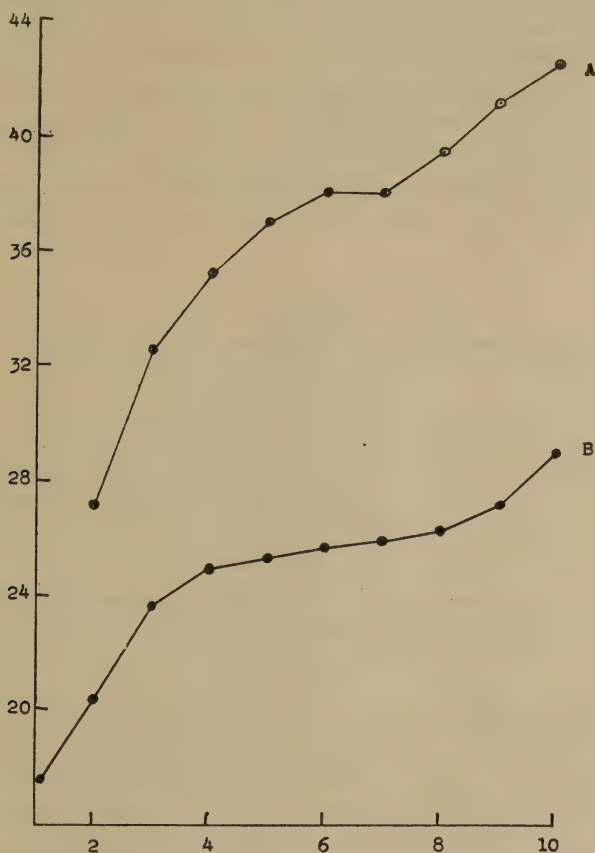


FIG. 5. EFFECT OF CONDITIONING, DISREGARDING HABITUATION
Ordinate: response strength in mn. mm. Abscissa: days. A: conditioning group corrected for habituation. B: conditioning group on days 1–10.

Group on the comparable day, that the factors of habituation are removed from the situation. Table V performs this addition, and figure 5, Curve A, shows the course of response of the Conditioning Group corrected for habituation. This curve, then, is taken to represent the amount of response strength generated by all non-habituatory factors in the situation.

Turning from habituation, we encounter several other nonassociative factors at work in the Conditioning Group: in view of the fact that in the Random-Order Group certain variables related to the UCS were demonstrated, a possibility must

be considered that in the Conditioning Group as well we have to do with these same variables. We are indeed forced to do so by our assumptions. Now when we consider the curve of response of the Conditioning Group, corrected for habituation as in figure 5, Curve A, it is suspected that the height of response represents the *sum* of the three factors of pseudo-conditioning, facilitation, and of course of association. This logically-derived conclusion is given some support by the observation that the shape of the curve would be distinctly anomalous if it represented *only* the factor of association. In the first place, the curve would in that case show association to have reached a fairly high level by the *second day*, which is almost absurd considering that only ten conditioning trials a day were given. Also, the general form of the curve exhibits little affinity with any comparable animal learning data. It is not too much to say that merely inspecting this curve, without regard to our structure of assumptions and manipulations, would lead one to suspect that more than one variable contributes to its formation.

TABLE V

*Effect of conditioning training disregarding habituation*

|  | MEAN AMPLITUDE PER DAY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 4 · | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 17.6 | 20.4 | 23.6 | 25.0 | 25.3 | 25.7 | 25.9 | 26.3 | 27.2 | 28.0 |
| 2 |  | 6.8 | 9.0 | 10.2 | 11.7 | 12.4 | 12.2 | 13.2 | 14.1 | 14.6 |
| 3 |  | 27.2 | 32.6 | 35.2 | 37.0 | 38.1 | 38.1 | 39.5 | 41.3 | 42.6 |

* 1 = Response of conditioning group. 2 = Amount by which habituation presumably influenced response. 3 = Response strength which conditioning group would have exhibited disregarding habituation.

The last and most important single factor, that of association, can be ascertained in a fairly direct manner. It has already been stated that in the responses of the Conditioning Group we may look for certain factors, and that in those of the Random-Order Group we may look for all of the same factors except that of association. We have merely to take the difference between these two groups to arrive at a quantitative estimate of the isolated factor of association. In other words, the difference in magnitude of response for each day between the two groups was taken to be the amount of response strength generated solely by the associative factor. It is, of course, immaterial whether the factors of habituation are removed from the responses of both groups before the difference is taken.

The course which such a procedure reveals the factor of association to take from day to day is of extreme interest. If it should conform to one of the main types of growth curves, as indeed figure 6, from Table VI indicates, it would seem that a strong presumption is afforded that the fundamental assumptions which we have made are sound.

The curve of growth of strength of conditioning is roughly S-shaped. More specifically: the curve begins at zero, as one would logically expect; the first

inflection occurs at the second or third day, and a second inflection at the seventh or eighth day. The curve thus approximates the form of one of the best-documented types of curves of growth of association.

There is no reason *a priori* to expect that by the end of 100 conditioning trials the strength of conditioning will have reached a maximum, but from figure 6
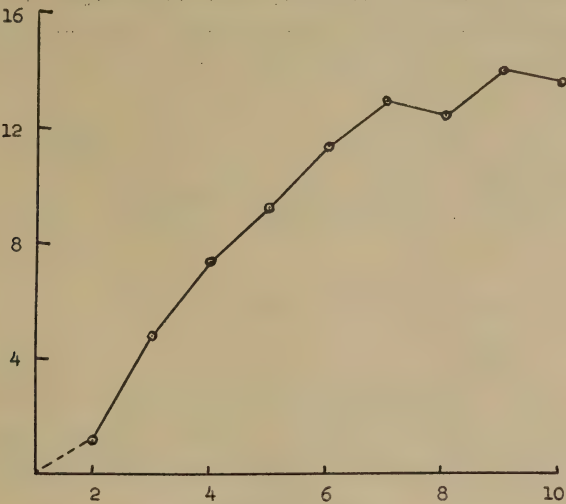


FIG. 6. GROWTH OF STRENGTH OF CONDITIONING
Ordinate: response strength in mn. mm. Abscissa: days.

TABLE VI
*Growth of strength of conditioning*

| | MEAN AMPLITUDE PER DAY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 17.6 | 20.4 | 23.6 | 25.0 | 25.3 | 25 7 | 25.9 | 26.3 | 27.2 | 28.0 |
| 2 | 20.2 | 19.3 | 18.8 | 17.6 | 16.0 | 14.3 | 12.8 | 13.7 | 13.0 | 14.1 |
| Diff......... | −2.6 | 1.1 | 4.8 | 7.4 | 9.3 | 11.4 | 13.1 | 12.6 | 14.2 | 13.9 |
| Sigma$_D$..... | | 2.7 | 2.8 | 1.9 | 2.4 | 1.6 | 1.7 | 1.7 | 1.5 | 1.9 |
| C. R........ | | .4 | 1.7 | 3.8 | 3.9 | 7.1 | 7.7 | 7.4 | 9.4 | 7.3 |

* 1 = Response of conditioning group.  2 = Response of random-order group.  Diff. = Amount of response strength generated by the associative factor.

one would expect further conditioning training to produce little effect. Here will be recalled the fact that, with a number of species, conditioning trials much in excess of 80–200 have given rise to negligible responses.

When, therefore, the response of the Conditioning Group is treated in the light of the assumptions and concepts introduced, it is clearly seen to be integrated with the body of work already done on the subject.

Not only does the shape of the curve of growth of conditioning reflect the

reliability and validity of the present experiments, but reciprocally it can be claimed that the results here discussed support in a very modest manner the general theory that the growth of a learned process has S-shaped characteristics. The present data of course justify only the statement that the course of response increment due solely to association has a bi-inflectional shape, a period of positive acceleration followed after an interval by a period of negative acceleration.

*5. The effect of facilitation and of pseudo-conditioning during subsequent "extinction."* Just as a comparison of the responses during training of the Random-
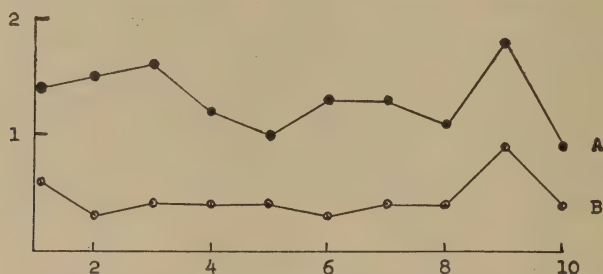


FIG. 7. EFFECT OF UCS FACTORS PER SE PLUS HABITUATION, AND OF HABITUATION ALONE,
DURING SUBSEQUENT "EXTINCTION"

Ordinate: response strength in mean mm. Abscissa: trials. A: random-order group during first "extinction" series. B: CS-habituation group during first "extinction" series.

TABLE VII

*Effect of UCS factors per se during "extinction"*

|  | MEAN AMPLITUDE PER TRIAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 1.7 | 1.8 | 1.7 | 1.3 | 1.0 | 1.3 | 1.3 | 1.5 | 1.7 | 1.6 |
| 2 | .5 | .2 | .4 | .3 | .4 | .2 | .5 | .3 | .8 | .6 |
| Diff......... | 1.2 | 1.6 | 1.3 | 1.0 | .6 | 1.1 | .8 | 1.2 | .9 | 1.0 |
| Sigma$_D$..... | .58 | .48 | .40 | .30 | .30 | .28 | .33 | .54 | .33 | .50 |
| C.R......... | 2.0 | 3.3 | 3.2 | 3.3 | 2.0 | 3.9 | 2.4 | 2.2 | 2.7 | 2.0 |

* 1 = Response of random-order group during the first "extinction" series. 2 = Response of CS-habituation group during the first "extinction" series.

Order Group and of the CS-Habituation Group showed the factors of facilitation plus pseudo-conditioning to be present in combination during training, so also can these factors taken together be shown to affect responses during "extinction." We compare the responses during "extinction" of the Random-Order and CS-Habituation Groups directly, all habituation factors up to the time of "extinction" being presumably identical. This comparison is made in figure 7 and Table VII. It is seen that throughout the "extinction" series the superiority of the Random-Order Group is reliably maintained as well as throughout training. There is no doubt that the effect is a genuine one, although a comparison

of the two groups during the second and third "extinction" series shows that the effect is lost after 24 hours (see App. 9 and 10).

It must be carefully noted that the difference between these groups during "extinction" is the result of facilitation *plus* pseudo-conditioning. It would seem that since in the nature of things the CS could be presented to the Pseudo-Conditioning Group only during the "extinction" series, it should be in this series that a distinction between facilitation and pseudo-conditioning can be made. Let us therefore examine the responses of the Random-Order and the Pseudo-Conditioning Groups during the "extinction" series.

Before any comparisons between the two groups are made, however, it is necessary to recall that the factor of CS-habituation has not been equated: one group has been exposed to 100 CS, the other to none. Fortunately we have at hand just the corrections to apply. In the case of the Random-Order Group it
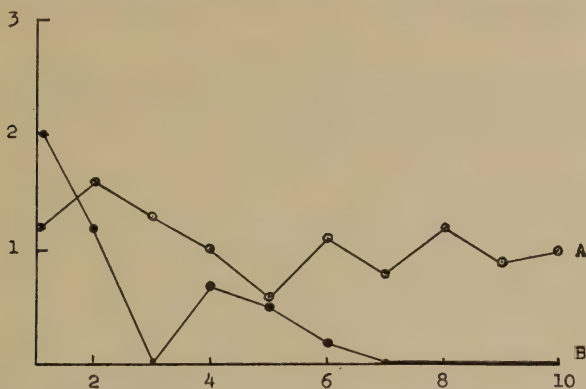


FIG. 8. EFFECT OF FACILITATION PLUS PSEUDO-CONDITIONING, AND OF PSEUDO-CONDITIONING ALONE, DURING SUBSEQUENT "EXTINCTION"

Ordinate: response strength in mean mm. Abscissa: trials. A: random-order group, corrected for habituation. B: pseudo-conditioning group, corrected for habituation (both during first "extinction" series).

is plain that we may use the data of the "extinction" series of the CS-Habituation Group, this group having had the same experience with the CS as the Random-Order Group. Furthermore, since habituation to the CS *during extinction* is presumably identical to all groups, we may utilize the most direct procedure of subtracting the responses of one group from those of the other in order to determine the effect of differences in training. Table VII subtracts the response strength of the CS-Habituation Group from that of the Random-Order Group. The result is depicted in figure 8, Curve A, representing the effect of facilitation plus pseudo-conditioning on responses during "extinction."

In the case of the Pseudo-Conditioning Group, on the other hand, our way is considerably less sure. Disregarding for the moment several important considerations, it would seem that the correction to apply to the responses of the Pseudo-Conditioning Group should be the responses for the same period of the Apparatus-Habituation Group, both of these groups having been in the ap-

paratus without CS for the same length of time. When the correction is made, however (see Table VIII), it is seen that the response strength, presumably due to pseudo-conditioning alone, is actually greater than that of our Table VII, the latter presumably due to pseudo-conditioning *plus* facilitation. Evidently something has been overlooked thus far in our argument.

One source of error may be in the correction applied to the Pseudo-Conditioning Group, where the responses of the Apparatus-Habituation Group were used. It will be recalled that the response of this group to the test series was, as the result of generalization, considerably lower than responses of rats completely naive to the apparatus and to the CS (see again fig. 3). Now the only reason for subtracting the responses of the Apparatus-Habituation Group from those of the Pseudo-Conditioning Group is the assumption that the same factor, generalization of habituation, which reduced the responses of the Apparatus-Habituation Group, operates likewise during "extinction" in the case of the

TABLE VIII

*Effect of pseudo-conditioning "corrected" for habituation, neglecting possible pseudo-conditioning to the apparatus*

|  | MEAN AMPLITUDE PER TRIAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 5.8 | 3.8 | 1.8 | 2.6 | 2.2 | 2.2 | 1.8 | 1.4 | 1.5 | 1.7 |
| 2 | 1.6 | 1.2 | .8 | 1.1 | .9 | .9 | .7 | .6 | .7 | .6 |
| 3 | 4.2 | 2.6 | 1.0 | 1.5 | 1.3 | 1.3 | 1.1 | .8 | .8 | 1.1 |

\* 1 = Response of pseudo-conditioning group during the first "extinction" series. 2 = Response of apparatus-habituation group during the first "extinction" series. 3 = Response strength of pseudo-conditioning group "corrected" for habituation.

Pseudo-Conditioning Group. The writer submits that this is by no means certain. A factor of habituation to the apparatus is by assumption posited in all experimental groups, but it seems extremely likely that, whatever apparatus-habituation occurs in the Pseudo-Conditioning Group, it is overcome by pseudo-conditioning *to the apparatus*. It is even possible that such pseudo-conditioning to the apparatus more than overcomes apparatus-habituation and becomes generalized in such a way as actually to increment pseudo-conditioning *to the CS*.

It is possible that the last argument is unjustified by the data, but at least, strong grounds have been offered against using the data of the Apparatus-Habituation Group as the corrective. If the factor of generalized apparatus-habituation can be disregarded, as seems permissible, then from the "extinction" responses of the Pseudo-Conditioning Group we should subtract the responses of the CS-Habituation Group on the first day of training. Table IX subtracts the responses, the result being depicted in figure 8, Curve B.

If the case is as we have argued, a direct comparison of the two curves in figure 8 should provide us with a better understanding of the comparative effects during "extinction," of facilitation and of pseudo-conditioning.

But when the comparison is made it is seen that Curve A, representing presumably *both* UCS factors, is not greatly higher than Curve B, representing only *one* factor—indeed, the first trial of Curve B is superior to Curve A. This initial superiority of the Pseudo-Conditioning Group may, in the absence of a better construct, tentatively be explained as the result of pseudo-conditioning to apparatus. Otherwise there is only the slightest evidence that the factor of facilitation of itself raises strength of response.

It is not permissible, however, to jump to the conclusion that since facilitation is not of great importance during extinction, it is not a real factor during conditioning. The concept of facilitation is in every case temporally restricted. Usually with paired reflexes a period of considerably less than a minute is sufficient for one reflex to lose its effect on another. If the facilitative effect found here followed this principle, the period of extinction would be longer than the effect of the UCS would last.

TABLE IX

*Effect of pseudo-conditioning corrected for habituation*

| | MEAN AMPLITUDE PER TRIAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 5.8 | 3.8 | 1.8 | 2.6 | 2.2 | 2.2 | 1.8 | 1.4 | 1.5 | 1.7 |
| 2 | 3.8 | 2.6 | 2.0 | 1.9 | 1.7 | 2.0 | 1.9 | 2.0 | 1.7 | 1.7 |
| 3 | 2.0 | 1.2 | −.2 | .7 | .5 | .2 | −.1 | −.6 | −.2 | 0.0 |

* 1 = Response of pseudo-conditioning group during the first "extinction" series. 2 = Response of CS-habituation group on first day. 3 = Response strength of pseudo-conditioning group corrected for habituation.

*6. The effect of conditioning training during subsequent extinction.* In view of the discussion above on the nature of the CR during conditioning, it is manifestly necessary for us to review the possibility that several factors are responsible for the response strength of the Conditioning Group during extinction. App. 12 presents the extinction data from this group. A glance at this appendix reveals a somewhat complicated shape of response strength when plotted against trials. We are able to bring out the factor of association in quite a direct manner: we simply subtract the response strength of the Random-Order Group from that of the Conditioning Group. Table X subtracts these groups, the result of which is shown in figure 9.

As for the shape of the curve of extinction as figure 9 would have it, we seek to know whether any of the commonly-known characteristics of extinction are met with. If so, that much more support will be added for the general applicability of the experiments, and in particular for the assumption that response strength bears a direct relationship to strength of conditioning.

The course of decrement of response strength itself during extinction has not been investigated in any comparable situation, to the writer's knowledge.

Direct comparison of the curve in figure 9 with that of other workers is therefore impossible.   Yet if our assumptions are sound we may compare this curve with other curves of responses the extinction of which was studied by other indices of strength of conditioning.   It is unnecessary to list here the several published curves of extinction showing the distinctive feature of figure 9, namely, an early rise in the strength of response (see for such a list, Hilgard and Marquis, 32).   It is sufficient here to state that considerable evidence has been gathered to support an early rise as a valid phenomenon in some situations.

TABLE X

*Effect of association per se*

| | MEAN AMPLITUDE PER TRIAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 2.7 | 2.8 | 3.4 | 2.4 | 2.0 | 2.0 | 1.8 | 1.6 | 1.9 | 1.9 |
| 2 | 1.7 | 1.8 | 1.7 | 1.3 | 1.0 | 1.3 | 1.3 | 1.5 | 1.7 | 1.6 |
| 3 | 1.0 | 1.0 | 1.7 | 1.1 | 1.0 | .7 | .5 | .1 | .2 | .3 |

* 1 = Response of conditioning group during first extinction series.   2 = Response of random-order group during first "extinction" series.   3 = Amount of response strength generated during extinction by previous association factor.
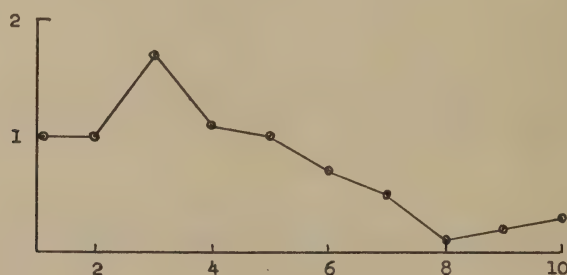


FIG. 9. EFFECT OF ASSOCIATION DURING SUBSEQUENT EXTINCTION
Ordinate: response strength in mm.   Abscissa: trials.   Response strength of conditioning group minus that of random-order group, both during first extinction series.

We may now examine whether any of the explanations offered in the cases spoken of apply to our data.   The writer feels that one of these explanations fits the present data remarkably well.   Hovland (33), on the hypothesis that learning involves a negative factor as well as a positive factor (see especially 35), explains that one will find an initial rise during extinction if the negative "potential" subsides more rapidly than the positive.   Later on, when the subsidence of positive potential will have "caught up" with that of its counterpart, the response will be less.

While the present data of course offer no crucial evidence for Hovland's explanation of initial rise, it is only fair to say that the commencement of the

present extinction series was carried out only seven and seven-eighths seconds after the termination of the last conditioning trial—i.e., well within the limits set by Hovland in his situation at least.   It is not unreasonable to relate our initial rise to the very early commencement of our extinction series.

In view of the similarity of the extinction curve of figure 9 to other extinction curves, and in view of a reasonable explanation of its chief feature, the combination seems enough to warrant the conclusion that we are dealing with actual strength-of-conditioning data when we measure response strength in this situation.

A glance at the results of the Random-Order Group and of the Conditioning Group for the second and third extinction series (see App. 9 and 13) shows that conditioning *per se* influences responses at least after 24 hours.

*7. What is the relation between conditioning and pseudo-conditioning?*   It is of little value for the argument of the present paper to compare the responses of the Conditioning Group and the Pseudo-Conditioning Group (both of course corrected for habituation), in view of the fact, established above, that the corrected responses of the Pseudo-Conditioning and of the Random-Order Group were generally similar.   However, much attention has been directed to the fact that in many situations, pseudo-conditioning training appears indistinguishable in its effects from *bona fide* conditioning: for that reason it is worth the trouble to compare the two types of training with the help of the present data.

Now every previous writer on the subject has felt justified to make the comparison between the two types of training on the basis of the raw responses of the groups during "extinction."   It has repeatedly been stated, in consequence, that pseudo-conditioning is just as effective a procedure as conditioning, in some cases even more so—and no really good explanation has as yet been offered for this apparent derogation of the old and certainly-established principle of contiguity or association.   But if the assumptions of the present discussion are pertinent, one should not compare such responses until all differentials between the groups have been removed from the situation, except conditioning and pseudo-conditioning.   This the previous authors have not always been inclined or able to do.   The experimental set-up described here is, on the other hand, well adapted to such a procedure.   All that is necessary is to compare the response strength of the Conditioning Group with that of the Pseudo-Conditioning Group, both groups corrected for habituation to the CS (see Tables XI and IX respectively).

Figure 10 graphically compares the two corrected groups and enables the reader to see at a glance that not only does conditioning as a type of training quite surpass pseudo-conditioning in producing response strength, but that after a couple of trials the factor of pseudo-conditioning may be practically disregarded.

But one may argue that the proper correction for habituation in the Pseudo-Conditioning Group should be the Apparatus-Habituation Group during "extinction," which the writer stated earlier is not at all admitted.   Purely for the

convenience of the reader, Table VIII so corrects the Pseudo-Conditioning Group. Still it is found that except for the first trial the Conditioning Group is either equal or superior.

This result seems strange, on the surface, in view of the more dramatic comparison of the uncorrected data from the Conditioning and the Pseudo-Conditioning Group. Evidently, at least in this situation, the importance of pseudo-conditioning, although it is certainly an active variable, may easily be

TABLE XI

*Effect of conditioning on subsequent extinction, corrected for habituation*

| | MEAN AMPLITUDE PER TRIAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 2.7 | 2.8 | 3.4 | 2.4 | 2.0 | 2.0 | 1.8 | 1.6 | 1.9 | 1.9 |
| 2 | .5 | .2 | .4 | .3 | .4 | .2 | .5 | .3 | .8 | .6 |
| 3 | 2.2 | 2.6 | 3.0 | 2.1 | 1.6 | 1.8 | 1.3 | 1.3 | 1.1 | 1.3 |

\* 1 = Response of conditioning group during first extinction series. 2 = Response of CS-habituation group during first "extinction" series. 3 = Response of conditioning group corrected for habituation.
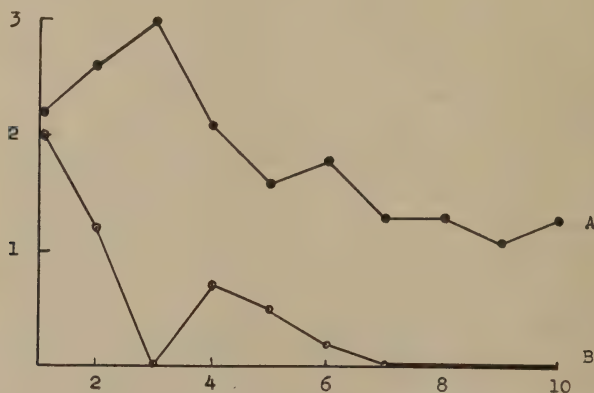


Fig. 10. Effect of Conditioning vs. Pseudo-Conditioning, during Subsequent Extinction

Ordinate: response strength in mn. mm. Abscissa: trials. A: conditioning group, corrected for habituation. B: pseudo-conditioning group, corrected for habituation.

overemphasized by hasty conclusions. Certainly there is no need for any alarm that the body of conditioning data may be set at nought by a simulacrum of the true CR.

### C. Conclusions of Experiment A

The set-up of Experiment A was intended to provide a typical conditioning situation in which a number of inherent nonassociative factors might have been expected to contribute to the actual strength of CRs. The demonstration

that such factors actually do influence magnitude of CRs is made with the aid of the assumption that any difference in strength of response can be referred to differences in training which the groups have received. It is emphasized that such a demonstration of the presence of any nonassociative factor in the results of a group given associative training is purely inferential. For example, the bare fact that the responses of one group of rats, given isolated presentations of a buzzer, shows a decline in magnitude, does not *of itself* warrant the conclusion that the responses of a similar group of rats, given repeated conditioning trials with the same buzzer as the CS, have anything in common with the responses of the first group. A number of assumptions and concepts have implemented the reasoning which concludes that the responses of one group of animals may help to interpret the responses of another group.

It should be said here in preparation for Experiment B that the demonstration of the actual influence of nonassociative factors may be made more direct than we have done as yet—i.e., with a smaller amount of inference. However, the chain of reasoning in Experiment A is not unwieldy, and moreover the data seem to confirm the logically derived predictions with only minor exceptions.

The details of Experiment A are briefed in the *General Summary* below. From the results of the procedures as outlined the following conclusions may be made:

1. Repeated exposure of a rat to the experimental apparatus and situation, but with no systematic stimuli, will cause the rat's level of general activity to decrement in habituatory fashion. The argument for the decrement being habituatory comes from two sources:

a. a day-by-day plot shows it to follow a negatively-accelerated curve quite typical of habituatory processes,

b. one important characteristic of habituation, namely, generalization, was shown to occur.

2. A factor of habituation to the CS is present during the process of conditioning and operates to reduce the magnitude of response.

3. The course which this factor takes is of negative acceleration, and by the end of ten days training the amount of effect is of great importance.

4. Factors arising as the result of presenting the UCS, irrespective of conditioning-type contiguity, are present during the process of conditioning, and operate to increase the magnitude of response both during conditioning and during extinction. It cannot be ascertained by Experiment A what the specific factors are. If more than one factor is at work, as we strongly suspect and as Experiment C will tend to show, the course which the individual factors pursue during conditioning is not known.

5. The course which the suspected combination of UCS factors takes reveals no especial trend during conditioning.

6. It is not perfectly clear what effect UCS factors *per se* have during subsequent extinction. The response during this period of the Pseudo-Conditioning Group is by far the most important—except of course that due to association. It is possible that pseudo-conditioning is the only UCS factor *per se* operating during extinction. The close dependence of the concept of facilitation upon

limited temporal intervals between activated reflexes makes it likely that any truly facilitative effect would have disappeared before extinction was begun.

The inconclusiveness of the argument rests on a slight superiority of the response during the initial "extinction" trial of the Pseudo-Conditioning over that of the Random-Order Group. It was very tentatively suggested that that increased response may represent the effect of generalization of previous pseudo-conditioning *to the apparatus*.

7. The fact that facilitation is suspected not to influence extinction does not bear on the possibility that it may be a real factor during conditioning.

8. When proper correction for habituation is applied, the resulting perspective tends to minimize the factor of pseudo-conditioning. It is concluded that while an analysis of nonassociative variables in any conditioning situation is imperative, there is no question of a *hysteron-proteron*.

9. Considering a day-by-day plot of what the response strength of the Conditioning Group during conditioning would presumably be if habituatory factors were removed, it is concluded that the shape and other characteristics of the curve indicate the presence of some other variables besides association.

10. When the single factor of association is isolated, a day-by-day plot over the period of conditioning exhibits roughly an S-shape. It is concluded that the correspondence of this description of the growth of learning with that of certain classical data lends experimental support to the assumption that magnitude of response is a direct function of strength of conditioning.

11. It is possible to describe for extinction a curve of response strength which is the result of association *per se*. The magnitude of such response exceeds that from any other factor.

12. The course during extinction both of the actual response strength of the Conditioning Group and of the theoretical effect of association on extinction, are observed to rise in the initial trials. The form of the curve approximates that of well-known extinction data, and it is concluded that the general formulations of the experiments receive experimental support. Especially is it concluded that the hypothesis of direct relationship between strength of response and strength of conditioning is affected.

V. EXPERIMENT B: THE INFLUENCE ON RESPONSE STRENGTH DURING CONDITIONING AND EXTINCTION OF PREVIOUS EXPERIENCE WITH THE CONDITIONING STIMULI

### A. Introduction

It was pointed out above that the theoretical treatment of Experiment A was accomplished with some indirection. That is, it had to be inferred with the aid of a somewhat complicated series of assumptions that isolated repetitions of typical conditioning stimuli have anything at all to do with actual conditioned response strength. Fortunately, it is not necessary to be content with so involved logic. It is possible to show directly that the processes of which we speak do materially affect later conditioned responses. This type of proof, in which the strength of CRs is actually altered, would seem much more impressive proof

of the importance of otherwise only hypothetical processes.   Experiment B continues the proof that nonassociative variables are present during conditioning by showing that habituation and pseudo-conditioning appreciably affect subsequent conditioning.

In the present experiment we present a group of rats with isolated repetitions of the CS.   During this training we observe that a factor of habituation is at work.   When later a period of conditioning intervenes, we note that the previous habituation training reduces the CR as compared with animals given no preliminary training.   Exactly the same reasoning is followed in the case of pseudo-conditioning.

But if nonassociative factors may be in one situation directly responsible for some of the magnitude of CRs, it is a short jump to conclude that in another situation as well—namely, actual conditioning—such factors may be of importance.

Experiment B may then be regarded as furnishing the experimental fact that nonassociative variables may affect CRs, and so provides evidence for one of our major conclusions, that during actual conditioning these factors must be reckoned with.

The specific types of training given to different groups in Experiment B are as follows:

*1. Conditioning group.*   Each rat of this group received ten conditioning trials a day for ten days, followed by three extinction series, and was in fact the Conditioning Group of Experiment A.

*2. Pre-sound group.*   Each rat of this Group received ten CS a day for ten days, in the usual temporal pattern.   On the 11th through the 20th day, ten conditioning trials a day for ten days were presented exactly as in the Conditioning Group.   The usual extinction series followed.

*3. Pre-shock group.*   Each rat of this group received ten UCS a day for ten days, in usual temporal pattern.   On the 11th through the 20th day, ten conditioning trials a day for ten days were presented exactly as in the Conditioning Group.   The usual extinction series followed.

In other words, three groups of rats were given typical conditioning and extinction training, all groups receiving exactly the same number of stimuli and in the same temporal pattern.   One of the groups had received no previous training whatever, one group had received 100 CS, and one group 100 UCS prior to conditioning.

## B. Results and Discussion

The suggestion that habituation and pseudo-conditioning are active mechanisms in the final common path of the conditioned response is lent considerable support by the results of Experiment B.   It can be shown:

1. That when animals are subjected to repetition of isolated stimuli, subsequent conditioning to that stimulus will produce somewhat less strength of CR than if the previous habituation training had not occurred, but

2. That the superiority of the Conditioning Group over the Pre-Sound Group

may be reduced by prolonged conditioning, so that during extinction the effect
is largely gone;

3. That when animals are subjected to repetitions of the isolated UCS, a
somewhat greater magnitude of CR will be recovered during subsequent condi-
tioning than if the previous pseudo-conditioning had not occurred, and

4. That the superiority of the Pre-Shock Group over the Conditioning Group
is maintained throughout most of the whole conditioning and extinction period.

The general problems which Experiment B raises are as follows:

1. *The effect of habituation to the apparatus and to the CS upon subsequent
conditioning and extinction.* A comparison of the results during the conditioning
period of the Pre-Sound Group with those of the Conditioning Group is facili-
tated by the consideration that all factors operating during the period of actual
conditioning are presumably identical. Any difference, therefore, in the re-

TABLE XII

*Effect of previous habituation to the CS*

| | MEAN AMPLITUDE PER DAY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 17.6 | 20.4 | 23.6 | 25.0 | 25.3 | 25.7 | 25.9 | 26.3 | 27.2 | 28.0 |
| 2 | 12.4 | 14.3 | 16.8 | 17.8 | 19.9 | 20.5 | 20.2 | 21.5 | 21.4 | 23.0 |
| Diff......... | 5.2 | 6.1 | 6.8 | 7.2 | 5.4 | 5.2 | 5.7 | 4.8 | 5.8 | 5.0 |
| Sigma$_D$..... | 2.47 | 2.46 | 2.52 | 1.86 | 2.46 | 2.15 | 2.03 | 1.76 | 1.89 | 1.86 |
| C.R......... | 2.1 | 2.4 | 2.8 | 3.8 | 2.2 | 2.4 | 2.8 | 2.7 | 3.0 | 2.6 |

* 1 = Response of conditioning group on days 1–10. 2 = Response of pre-sound group
on days 11–20.

sponse during this period may be ascribed to the previous habituation of the
Pre-Sound Group. In Table XII and in figure 11, Curves B and C, will be
found the comparison. A clear and fairly reliable difference appears through-
out. It is plain that prolonged habituation to the CS will to some degree affect
response strength during a later conditioning period. A graphic approximation
of the extent of this influence is found in the area between the curves of the
two groups.

The the superiority of the non-habituated group may be overcome with pro-
longed conditioning is quite possible. Indeed it is to be expected at some
point in conditioning after habituation to the CS in the case of the Conditioning
Group has proceeded to zero or near zero. In figure 11 it is plain that the
point has not yet been reached. This is of course no evidence that such a
point does not exist.

Some evidence on this point comes from the results of the two groups during
the extinction series. Figure 12, Curves B and C, graphically describes the
comparison.

After 100 conditioning trials no very significant difference is found during

extinction. Here there is little more than an early trend in favor of the Conditioning Group. Moreover all differences are lost by the second extinction series, as App. 13 and 16 show.

In spite of the possibility that the effects of habituation may be partially, perhaps completely overcome, however, the inference seems warranted that habituation does operate in actual conditioning.

*2. The effect of pseudo-conditioning upon subsequent conditioning and extinction.* Evidence confirming and extending the observation of Wickens on the



FIG. 11. EFFECT ON CR OF PREVIOUS EXPERIENCE WITH THE CONDITIONING STIMULI
Ordinate: response strength in mn. mm. Abscissa: days. A: pre-shock group on days 11–20. B: conditioning group on days 1–10. C: pre-sound group on days 11–20.

effect of previous pseudo-conditioning on conditioning is gathered in a comparison of the results during conditioning of the Pre-Shock Group with those of the Conditioning Group (see Table XIII). Figure 11, Curves A and B, renders the comparison easy for the reader. Curve A, representing the response strength of the Pre-Shock Group during conditioning, is unique and beyond question involves several variables. Easily distinguished is a tendency beyond doubt in the nature of pseudo-conditioning and lasting at least two or three days. Thereafter the curve assumes the same general shape as that of the Conditioning Group, but is incremented throughout the period. This latter

increment probably is due to the previous pseudo-conditioning, although the statistical reliability is not great.

TABLE XIII

*Effect of previous pseudo-conditioning with the UCS*

| | MEAN AMPLITUDE PER DAY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1* | 32.4 | 26.4 | 25.5 | 27.0 | 27.8 | 29.0 | 27.7 | 30.3 | 29.8 | 31.0 |
| 2 | 17.6 | 20.4 | 23.6 | 25.0 | 25.3 | 25.7 | 25.9 | 26.3 | 27.2 | 28.0 |
| Diff........ | 14.8 | 6.0 | 1.9 | 2.0 | 2.5 | 3.3 | 1.8 | 4.0 | 2.6 | 3.0 |
| Sigma$_D$..... | 3.14 | 3.0 | 3.4 | 3.0 | 2.5 | 2.27 | 2.06 | 2.0 | 2.23 | 2.16 |
| C.R........ | 4.7 | 2.0 | .5 | .6 | 1.0 | 1.4 | .8 | 2.0 | 1.1 | 1.4 |

* 1 = Response of pre-shock group on days 11–20.   2 = Response of conditioning group on days 1–10.
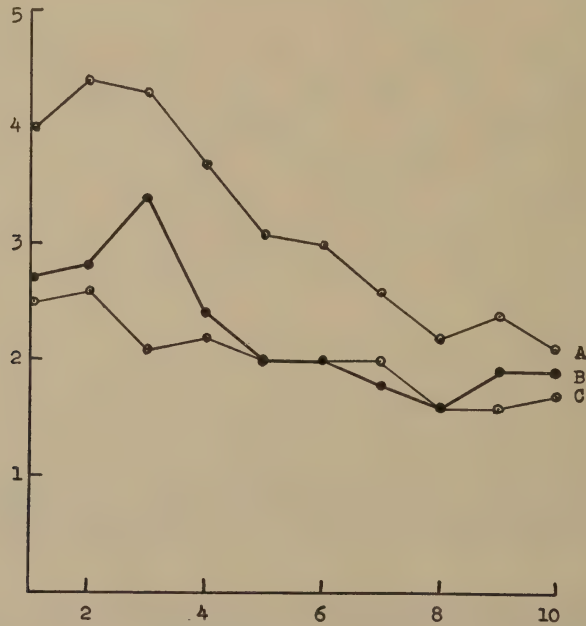


FIG. 12. EFFECT ON CR, DURING EXTINCTION, OF PREVIOUS EXPERIENCE WITH THE CONDITIONING STIMULI

Ordinate: response strength in mn. mm.   Abscissa: trials.   A: pre-shock group during extinction.   B: conditioning group during extinction.   C: pre-sound group during extinction.

Figure 12, Curves A and B, demonstrates that the superiority of the Pre-Shock Group is quite marked during immediate extinction, while a comparison during the second and third extinction series (App. 13 and 19, representing

responses respectively of the Conditioning and Pre-Shock Groups) shows the tendency to continue at least 48 hours.

The results of the Pre-Shock Group confirm the conclusions of the preceding experiment in the following manner: there it was seen that while pseudo-conditioning might be suspected during actual conditioning, nothing could be proved definitely since it was necessary obviously to wait until the extinction series to test for the presence of pseudo-conditioning. While the extinction series suggested the presence of some factor other than facilitation as a consequence of the UCS, still it could be contended that it is largely gratuitous to assume the presence of a process during *conditioning* merely because of some effect appearing during *extinction*.

It is claimed that the present experiment puts on a sounder experimental basis the hypothesis of a pseudo-conditioning effect during conditioning. It certainly cannot be contended that the incremented response of the Pre-Shock Group was due to facilitation, hence the next most likely construct, that of pseudo-conditioning, is strongly indicated.

## C. Conclusions

The arrangement of Experiment B was such as to provide a favorable opportunity for the nonassociative variables of habituation and of pseudo-conditioning actually to influence magnitude of CRs during subsequent conditioning and extinction. We are able to make the following conclusions:

1. That isolated presentations of the CS and of the UCS in this situation do give rise to factors of habituation and pseudo-conditioning respectively,

2. That these factors operate during subsequent conditioning to reduce and to increase respectively the magnitude of CRs,

3. That in view of this demonstration that strength of CRs may in one situation be directly influenced by nonassociative factors, strong support is furnished for the hypothesis that nonassociative factors may so influence CRs during actual conditioning. It is probably impossible to document such a statement directly, that is, without the aid of *any* collateral assumptions, and it is concluded that the argument of Experiment B, agreeing as it does with inference from Experiment A, provides all the proof one could reasonably ask.

### VI. EXPERIMENT C: A GRADIENT OF PSEUDO-CONDITIONING

#### A. Introduction

Experiment C has a dual purpose, first, to provide a temporal gradient of pseudo-conditioning—the relation between strength of pseudo-conditioning and number of presentations of UCS being very imperfectly known; and second, to implement the present series of studies with a curve of pseudo-conditioning effect which can be manipulated along with the other variables of habituation, facilitation, and association. The first purpose becomes important as a result of the suggestion of Wickens and Wickens that pseudo-conditioning may be a manifestation of a conditioning process, the CS of which is obscure from the

experimenter. If this is true, then with succeeding numbers of stimulations the effects of pseudo-conditioning should show some incremental characteristics relating it to other growth processes. It seems that this is the minimum correspondence which pseudo-conditioning should show with other learned processes. If the "gradient" of pseudo-conditioning does not exhibit any resemblance to any known learning curve, the learning hypothesis will have been to some extent discredited.

Our second purpose in obtaining a curve of pseudo-conditioning effect is to complete our quantitative analysis of nonassociative factors. It will be recalled that by no means in Experiment A were we able to determine the separate effects of the UCS *per se* during conditioning. Experiment C enables us to perform that analysis.

What we need is a measure of how much the factor of pseudo-conditioning *alone* contributes to the strength of CR on each day of our Conditioning Group.

If we had the measure arranged as a day-by-day plot it would be possible, and quite in line with our foregoing manipulations, to compare it directly with similar day-by-day plots of the course of other factors in the situation. As a matter of fact it is quite easy to construct the day-by-day plot which we require.

The specific training given to the rats in this experiment was as follows:

*Group 0:* Each rat of this group received one day of conditioning training, and was in fact the Conditioning Group of the preceding experiments.

*Group 1:* This group received ten UCS a day for one day, exactly as the Pseudo-Conditioning Group of Experiment A, followed on the second day by ten conditioning trials as in the Conditioning Group.

*Group 2:* This group received ten UCS a day for two days, followed on the third day by ten conditioning trials as above.

*Group 3:* This group received ten UCS a day for three days, followed on the fourth day by ten conditioning trials as above.

*Group 5:* This group received ten UCS a day for five days, followed on the sixth day by ten conditioning trials as above.

*Group 7:* This group received ten UCS a day for seven days, followed on the eighth day by ten conditioning trials as above.

*Group 10:* This group received ten UCS a day for ten days, followed on the 11th day by ten conditioning trials as above, and was in fact the Pre-Shock Group of Experiment B.

Individual groups were thus given 0, 1, 2, 3, 5, 7, and 10 days of shock training, followed by a day of conditioning training. Using the responses of Group 0 as a base, it is possible to ascribe any increment of response of Groups 1–10 over that of the "base" group as due to the factor of pseudo-conditioning. The increments thus obtained, plotted against days of shock-training, constitute what is called the "gradient of pseudo-conditioning."

The reader will immediately be on his guard against the tendency to compare Group 1, for instance, of Experiment C, with the responses of the Conditioning Group *on Day 1*. It is to be noted that Group 1 has already had a day's training with shock, while this is not true of Day 1, but of *Day 2* in the Conditioning

Group.   Accordingly in comparing day-by-day plots of the "gradient of pseudo-conditioning" with the responses of any of the previous groups an appropriate allowance must be made.

### B. Results and Discussion

*1. The factor of pseudo-conditioning.*   The raw data of Experiment C are condensed in App. 20.   It will at once be seen that the average responses of the different groups vary, which of course means that it makes some difference to the CR whether we precede conditioning with pseudo-conditioning training, and further, it matters how prolonged the preceding training has been.

It is clear that the results of App. 20 are of little value in themselves so far as we are concerned at the moment.   It is only if we are able to abstract the

### TABLE XIV
*The gradient of pseudo-conditioning*

|  | MEAN AMPLITUDE OF RESPONSE DAYS SHOCK TRAINING PRECEDING ONE DAY OF CONDITIONING | | | | | |
|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 5 | 7 | 10 |
| Group 0.... | 31.0 17.6 | 24.7 17.6 | 25.7 17.6 | 25.7 17.6 | 26.3 17.6 | 32.4 17.6 |
| Diff........ | 13.4 | 7.1 | 8.1 | 8.1 | 8.7 | 14.8 |
| Sigma$_D$..... | 3.36 | 2.6 | 3.6 | 3.9 | 2.9 | 3.1 |
| C.R........ | 3.9 | 2.7 | 2.2 | 2.0 | 3.0 | 4.7 |

*Effect of pseudo-conditioning on responses to CS during subsequent conditioning*

| 13.4 | 7.1 | 8.1 | *8.1* | 8.1 | *8.4* | 8.7 | *10.7* | *12.7* | 14.8 |
|---|---|---|---|---|---|---|---|---|---|

Italic figures = interpolated value.

course of effect of the isolated factor of pseudo-conditioning that the results will be of value.   We have only to concede that the responses of the Conditioning Group represent the effect of one day's conditioning uncomplicated by any pseudo-conditioning effect, while any increase over this level in the case of the Groups 1–10 is a representation solely of this latter effect.   We simply subtract the response level of Group 0 from that of all other groups, as Table XIV indicates.

In the arrangement of Experiment C it was not considered necessary to present groups with every number of days of shock from one to ten.   For those days of the Conditioning Group for which we have no direct control in Experiment C, therefore, we merely interpolate a value.   Enough groups were run so that the interpolation does not in all probability distort the picture seriously.   Table XIV, then, presents the so-called gradient of pseudo-conditioning, and figure 13 graphically depicts the same.

The first purpose of Experiment C has now been accomplished: we have a quantitative description of the relation between strength of pseudo-conditioning and amount of experience with the UCS. The gradient of figure 13 will obviously have no simple explanation. Several possibilities must be kept in mind. It is clear that two opposed tendencies interact in the situation, one tending to reduce pseudo-conditioning and the other tending to increase it. The writer feels that the decrement observed after two or three days of UCS is closely related to a similar decrement in the case of response *to the shock* when the latter is repeatedly presented alone (see Harris, 21). In other words, the rats of Group 1 came to the day of conditioning fresh from responses to shock to which they responded maximally, while rats of Group 5, for example,
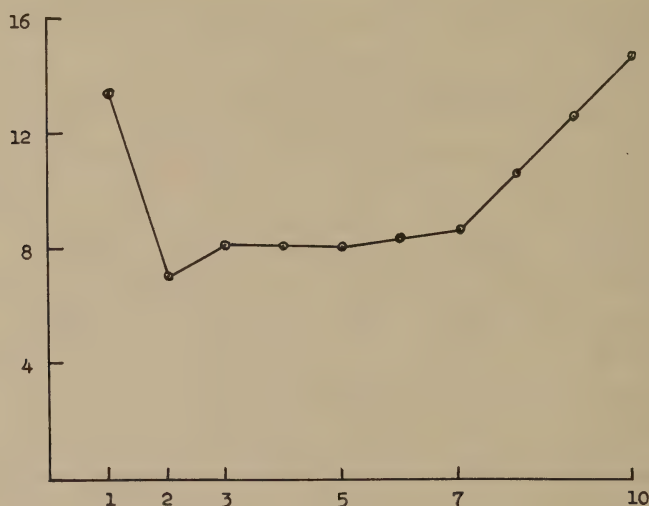


FIG. 13. A GRADIENT OF PSEUDO-CONDITIONING

Ordinate: increase in mean response during first day of conditioning, of groups 1–10 over that of group 0. Abscissa: groups 1–10, or, days of experience with UCS prior to first day of conditioning.

had had several days of experience with that shock. The shock in the latter case may have become considerably less potent as the result of habituation.

In any case, the rise in response amplitude after three to five days of shock training must have another explanation. Of the explanations of pseudo-conditioning which have been given, the raised excitability—dominance type of explanation would call for a rise in pseudo-conditioning effect with relatively short intervals between trials; but it must be remembered that the intervals between trials in the present case were as long as 24 hours. Furthermore, the supposition that pseudo-conditioning consists in the formation of attitudes of "expectancy" has been ingeniously disproved for the rat at least by Wickens and Wickens (65).

In the writer's opinion the phenomenon is allied more reasonably with the general data of learned responses, and he therefore concludes that the Wickens'

hypothesis of pseudo-conditioning as a phenomenon of learning receives some experimental support.

As to what is learned, there may be some question.  The Wickenses contend that pseudo-conditioning was a result of sensory generalization in Pavlovian conditioning.  In the present situation there may have been enough subtle similarities between the CS and the UCS to make their explanation the preferred one.  There is, however, the possibility that one thing the rat learns from being placed day after day in the shock situation, is a condition of raised excitability which comes to be evoked more and more by the experimental apparatus and situation.  Such a combination of the dominance and the learning hypotheses would not be neurologically absurd.  But although it seems
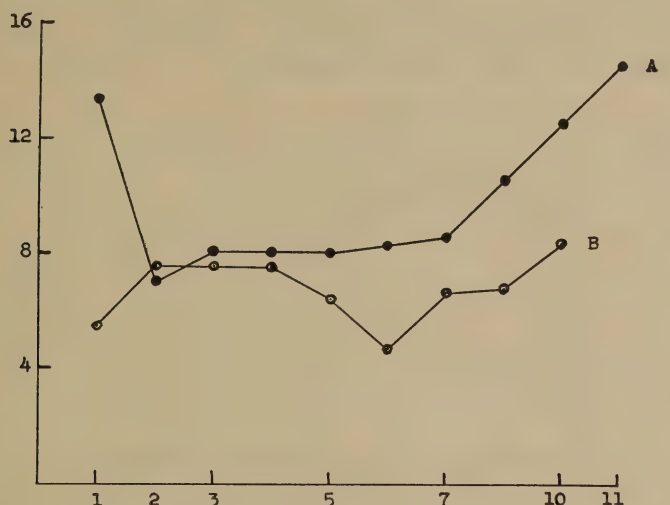


FIG. 14. EFFECT OF ALL UCS FACTORS PER SE, AND OF PSEUDO-CONDITIONING ALONE
    Ordinate: presumed response strength, in mm., generated by nonassociative UCS factors. Abscissa: days.   A: the gradient of pseudo-conditioning.   B: effect of all UCS factors per se.

applicable here, it would admittedly not be the best explanation for certain other instances of pseudo-conditioning.

2. *The factor of facilitation.*  Having constructed a gradient of pseudo-conditioning, we are now ready to determine its usefulness for the general argument of this paper.

It will be recalled that the response of the Random-Order Group of Experiment A provided us with a day-by-day plot of the effect of all UCS factors *per se.*  Comparison of the course of the *combination* effect of facilitation and pseudo-conditioning, with that of pseudo-conditioning *alone*, should then aid us to isolate the factor of facilitation.  Figure 14, a recapitulation, graphically compares the combination (Curve B) with the single factor (Curve A).

The conclusions which one may reach from the comparison in figure 14 are by no means directly arrived at.  According to the simplest manner of con-

ceiving the effects it should be that the effect of a combination exceed that of
either factor alone.   Yet Curve B is in some cases less than Curve A.   The
superiority of pseudo-conditioning during the first day or two is probably ex-
plained correctly as an artifact of some exaggerated effect of shock—such as
some early generalization effect or some extreme potency before habituation
sets in—which we do not know certainly.   On the other hand, the explanation
of the sustained superiority during the last days of training is more obscure.

There are two possibilities, first, that we are dealing here not with *facilitation*,
but with *inhibition*, and second, that the relative magnitudes which we are
comparing are taken from an erroneous absolute level of response strength.

In the latter connection it will be remembered that Base Group 0 of Experi-
ment C was actually the Conditioning Group of Experiment A.   Now the ani-
mals of the two experiments were of somewhat different genetic characteristics
since the dams of the rats in the last experiment were third-litter pups of the



FIG. 15. COURSE OF THE EFFECT OF FACILITATION
Ordinate: arbitrary scale.   Abscissa: days.

dams of the first experiment.   Furthermore, with the latest groups the sire
was a year older.   It may well be, therefore, that the absolute magnitude of
response of Group 0 on the first day of conditioning was really lower than the
"true" base.

Granting for the moment that facilitation and not inhibition is involved,
let us artificially raise the level of the "combination" curve and subtract from
it the "pseudo-conditioning" curve, to see what course the remaining factor
pursues.   After doing this it is obvious that a zero point on the ordinate has
no meaning, although the values on the abscissa remain the same.   In other
words, the procedure does not distort the picture of the *course from day to day*
which the isolated factor takes.   Figure 15 portrays this course.

Considering the curve in Figure 15, we can from its shape come to some
conclusion as to the variable the effect of which it represents.   Neglecting the
initial apparent lack of effect as in one sense incidental, and not truly represent-
ing the course of the variable, a gradual decrement from days three or four to

ten is apparent.   The writer contends that the decline in magnitude of response is in all likelihood directly related to an habituatory decline in magnitude of response to the shock.   If the shock becomes physiologically less potent as we suppose, its facilitatory (or inhibitory) effect would decrease proportionately, in accordance with well-established principles of reflex physiology.   But the reader is invited to notice that if it were an *inhibitory* effect which grows less pronounced, the curve in figure 15 should *rise*; on the other hand, if the effect were facilitatory the curve should decline.

The writer reasons that the exactly opposed effects which are predicted by the concepts of facilitation and of inhibition, and the correspondence of the data with the expectation of facilitation, make it necessary to conclude that the UCS factor involved is that of reflex facilitation.

## C. Conclusions

Experiment C was arranged so as to provide a quantitative characterization of the dependence of strength of pseudo-conditioning upon the amount of previous training with the UCS, described in such fashion that it could be compared directly with other day-by-day plots of the course of other factors contributing to the CR.   The successful description of a "gradient" of pseudo-conditioning permits us to say:

1. That previous experience with the UCS makes a difference in the strength of CRs during subsequent conditioning,

2. That the characteristics of the course of the gradient of pseudo-conditioning ally it to learning data and so lend support to the hypothesis of pseudo-conditioning as in part a learning phenomenon,

3. That removing the factor of pseudo-conditioning from the totality of UCS factors *per se* leaves a curve of gradually decreasing magnitude, which it is concluded represents a facilitation effect, but

4. That the absolute levels of effect cannot be ascertained from these data.

### VII. GENERAL SUMMARY AND CONCLUSIONS

It was the purpose of the series of experiments reported here to analyze quantitatively the role played in conditioning by the nonassociative variables of habituation, pseudo-conditioning, and facilitation, and by the associative variable itself.   Sound-shock conditioning in rats was chosen as the conditioning situation to be analyzed.   General body responses were recorded pneumatically. The CS was two seconds of a loud, complex noise, the UCS was electric shock. Maximum response to a particular stimulus was measured; mean and median responses were compared from group to group.

In Experiment A a group of rats was given ten conditioning trials a day for ten days.   An extinction series of ten CS was presented seven and seven-eights seconds after the termination of the last conditioning trial.   Twenty-four and again 48 hours afterward a second and a third extinction series were presented. It was the purpose of the experiment to determine what magnitude of response was contributed by the nonassociative variables, in the case of the CRs during

conditioning and extinction of the Conditioning Group. When the contributions of these nonassociative factors were mathematically removed, it was a second purpose of the experiment to ascertain the course of effect of the associative factor itself.

With groups of rats comparable to those of the Conditioning Group, the following control procedures were instituted:

*Apparatus-habituation group:* merely placed in the apparatus for a time comparable to the Conditioning Group, and presented thereafter with the same "extinction" series.

*CS-habituation group:* given same sequence of CS as Conditioning Group, no UCS whatever being given.

*Preudo-conditioning group:* given some sequence of UCS as Conditioning Group, without any CS until the usual extinction series.

*Random-order group:* given same number of CS and UCS as Conditioning Group but arranged to preclude association; the usual "extinction" series followed.

From the procedures of Experiment A we obtain a quantitative description of the factors of apparatus-habituation and CS-habituation. We obtain a measure of the extent of generalization of apparatus-habituation. We obtain a quantitative description of the effect of the combination of UCS factors *per se*, both during conditioning and during extinction, and we finally obtain a quantitative description of the effect during conditioning and during extinction of association *per se*.

In Experiment B the Conditioning Group of the preceding experiment was used as a control, and two other groups were compared to it. One, the Pre-Sound Group, received ten days of experience with the CS, and the other, the Pre-Shock Group, received ten days of experience with the UCS. Subsequently both groups were given exactly the same ten days of conditioning training as the control.

From the procedures of Experiment B we obtain an almost completely direct proof that nonassociative factors actually affect strength of CRs, in that an effect established beyond doubt as habituation will reduce strength of subsequent CRs, and that the similarly-established pseudo-conditioning will increase such responses.

In Experiment C, seven groups of rats were given one day of conditioning training. Individual groups had previously been subjected to 0, 1, 2, 3, 5, 7, and 10 days of experience with the UCS. Any increase in level of response, on the one day of conditioning, over that of Group 0 was considered an index of the strength of pseudo-conditioning for that group.

From the procedures of Experiment C we obtain a day-by-day plot of pseudo-conditioning effect. This "gradient," when compared with a similar plot of the effect of *all* UCS factors *per se*, enables us to describe the course, though not perhaps the actual magnitude, of effect of the factor of facilitation.

Experiment C thus completes the assigning of specific roles in conditioning, of apparatus-habituation, CS-habituation, facilitation, pseudo-conditioning,

and finally that associative factor related directly to the temporal contiguity of stimuli in conditioning training.

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## APPENDIX 1

*Response amplitude in millimeters*

| RAT NO. | APPARATUS-HABITUATION GROUP DAYS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 9 | 5½ | 1½ | 1 | 0 | ½ | 0 | 2½ | 0 | 1½ | ½ |
| 16 | 13½ | 10 | 1½ | 2½ | 0 | 1 | 2½ | ½ | 2½ | 0 |
| 57 | 18 | 8½ | 2 | 3½ | 2 | 3½ | 6 | 2½ | 1½ | 4½ |
| 113 | 14½ | 8½ | 8 | 5½ | 5 | 8 | 4 | 5½ | 9½ | 4½ |
| 147 | 11½ | 3 | 2½ | 1 | ½ | 0 | 0 | 0 | 0 | 0 |
| 301 | 11½ | 8 | 6 | 4½ | 4½ | 2½ | 5½ | 1½ | 2½ | 6½ |
| 303 | 10½ | 21 | 13½ | 9 | 10 | 2½ | 5½ | 0 | 3 | 2 |
| 305 | 5½ | 9½ | 3 | 5½ | 4½ | 4½ | 2½ | 2½ | 3½ | 2½ |
| 307 | 24½ | 17 | 9½ | 11½ | 6 | 5½ | 6 | ½ | 3½ | 3 |
| 309 | 3½ | 3½ | 1½ | 2 | 0 | 1½ | 0 | 1 | 2 | 4½ |
| 311 | 9½ | 9 | 11 | 5 | 2 | 4½ | ½ | 1½ | 4 | 3½ |
| 313 | 14½ | 10 | 11½ | 14 | 9 | 3 | 4 | 7½ | 3 | 3½ |
| 315 | 7½ | 11 | 12½ | 4½ | 4 | 3 | 1½ | 1½ | 2½ | 1½ |
| 317 | 27½ | 15 | 8 | 2 | 4 | 2½ | 5½ | 2½ | 6 | 5 |
| 319 | 7½ | ½ | 1 | 1 | ½ | 2½ | ½ | 11 | 6 | 2½ |
| 321 | 3½ | 14 | 7 | 7½ | 7 | 3 | 2½ | 2 | 1 | 4½ |
| Total....... | 188½ | 150 | 99½ | 79 | 59½ | 47½ | 49 | 40 | 52 | 48½ |
| Mean....... | 11.7 | 9.3 | 6.2 | 4.9 | 3.7 | 2.9 | 3.0 | 2.5 | 3.2 | 3.0 |
| Sigma$_M$..... | 1.60 | 1.21 | .97 | .87 | .74 | .69 | .51 | .34 | .57 | .44 |
| Median..... | 10.8 | 9.0 | 6.0 | 4.4 | 3.5 | 3.0 | 3.5 | 1.7 | 3.0 | 3.2 |

## APPENDIX 2

*Response amplitude in mm.*

| RAT NO. | CS-HABITUATION GROUP TRIALS DURING FIRST "EXTINCTION" | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 5 | 3½ | 0 | 1 | ½ | 0 | 0 | 0 | 0 | 0 |
| 21 | 5 | 3 | 1½ | ½ | 2 | ½ | 0 | 0 | 1 | 2 |
| 23 | 11 | 3 | 2 | 1 | 1 | ½ | ½ | ½ | 1 | ½ |
| 47 | 5½ | 3 | 4 | 2 | 3 | 2 | 2 | 5 | 4 | 3 |
| 49 | 5 | 10 | 6 | 4 | 3 | 5 | 3 | 3 | 4 | 3 |
| 73 | 2 | ½ | 0 | 0 | 0 | 1½ | 0 | 0 | 0 | 0 |
| 87 | 1 | 0 | 0 | 2 | ½ | 0 | 0 | 0 | 0 | 0 |
| 101 | 2½ | 1½ | ½ | ½ | 1½ | 2 | 1½ | 1½ | 1 | 1½ |
| 119 | 3 | 2 | ½ | ½ | ½ | 0 | 0 | 0 | 0 | 0 |
| 132 | 1 | 2½ | ½ | ½ | 0 | 0 | 0 | 0 | 0 | 0 |
| 135 | 0 | ½ | ½ | 3 | ½ | 1 | 1½ | 1 | 1 | ½ |
| 138 | 4 | 2 | 2 | 0 | ½ | 0 | 0 | 0 | 0 | 0 |
| 140 | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 142 | 5 | 1½ | 0 | 3 | 2½ | 5½ | 0 | 3 | 2½ | 1 |
| 144 | ½ | ½ | ½ | 0 | 0 | ½ | 0 | 0 | ½ | 0 |
| 158 | 4½ | 3 | ½ | 1½ | 0 | 2 | 1 | 1½ | ½ | 2 |
| 178 | 4 | 3 | 4 | 6 | 4 | 4 | 3 | 7 | 2½ | 3 |
| 180 | 3½ | 6½ | 5 | 3 | 1½ | 2½ | 1½ | 1 | ½ | 4½ |
| 187 | 7½ | 4½ | 2 | 1½ | 4½ | 2 | 2 | 0 | 6½ | 0 |
| 193 | 2½ | 3 | 2 | 4½ | 2 | 2 | 6½ | 4 | 3 | 8 |
| 195 | 2½ | 2 | 1½ | 2 | 2 | 1 | 5 | 1 | ½ | 0 |
| 201 | 4½ | 3½ | 5 | 7 | 2 | 6 | 5 | 5 | 3 | 5½ |
| 205 | 2 | 3½ | 2 | 2 | 2½ | 3½ | 1 | 1½ | 3½ | 4 |
| 219 | 10 | 2 | 2½ | 5 | 5 | 3½ | 3 | ½ | 1½ | 0 |
| 221 | 2 | 3 | 5 | 3 | 1½ | 5½ | 1½ | 5 | 2 | 3 |
| 226 | 5 | 1½ | 2 | 2 | 1 | 2 | 1½ | 3 | 1 | 2 |
| 233 | 8½ | 2 | ½ | 1 | 2 | 2 | 3 | ½ | 3 | ½ |
| 243 | 3 | 1 | 2 | 1 | 2½ | 3½ | 3 | 7 | ½ | 1 |
| 249 | 6 | 2½ | 2 | 2 | 1 | 1½ | 2½ | 4 | 3 | 1½ |
| 250 | 7 | 6 | 4 | 2 | 4½ | 1½ | 4 | 4 | 2½ | 7 |
| 251 | 2 | 3 | 1½ | 1 | 2 | 2½ | 1½ | 1 | ½ | 1½ |
| 260 | 1 | 2 | 3 | 1 | 2 | 1 | 5 | 4½ | 3½ | 1½ |
| 263 | 2½ | ½ | 2 | 1 | 1 | 1½ | 0 | 1 | 2 | 1½ |
| 267 | ½ | 2 | 4½ | 1½ | 1½ | 2 | 6 | 5 | 2 | 2 |
| Total....... | 132 | 91 | 69 | 67 | 58 | 68 | 64½ | 68½ | 58½ | 60 |
| Mean....... | 3.8 | 2.6 | 2.0 | 1.9 | 1.7 | 2.0 | 1.9 | 2.0 | 1.7 | 1.7 |
| Sigma$_M$.... | .44 | .34 | .26 | .32 | .22 | .28 | .32 | .39 | .26 | .36 |
| Median..... | 3.8 | 2.7 | 2.2 | 1.9 | 1.9 | 2.1 | 1.6 | 1.3 | 1.8 | 1.4 |

## APPENDIX 3

*Response amplitude in mm.*

| RAT NO. | APPARATUS-HABITUATION GROUP TRIALS DURING FIRST "EXTINCTION" | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 9 | 1 | 1 | ½ | 1 | 1 | 1½ | 1½ | ½ | 1 | ½ |
| 16 | ½ | 1 | 1 | 1 | ½ | ½ | ½ | ½ | ½ | 0 |
| 57 | 3 | 2 | 2 | 1½ | 1 | 1½ | 1 | 1½ | 2 | ½ |
| 113 | 1½ | ½ | 1 | 1½ | 2 | 3 | ½ | 1½ | 1 | 1 |
| 147 | ½ | ½ | 0 | 0 | 0 | 0 | ½ | 0 | 0 | 0 |
| 301 | 1½ | 1½ | 0 | 1 | 0 | 1 | ½ | ½ | 0 | 0 |
| 303 | 2 | ½ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 305 | 1½ | 1 | 1 | 2 | 2 | ½ | 1½ | 1 | 1 | 2 |
| 307 | 2 | 1½ | ½ | 0 | ½ | ½ | 1 | 1 | 0 | 0 |
| 309 | 1½ | 1½ | 0 | 0 | 1 | 0 | 0 | 0 | ½ | 0 |
| 311 | 1 | 0 | 1 | 1½ | 1 | 1 | ½ | 1 | ½ | ½ |
| 313 | 1½ | 2 | 0 | 0 | 0 | 0 | 0 | 0 | ½ | 0 |
| 315 | 3 | 3 | 2 | 2 | 2 | 1½ | 2 | 1 | 1 | 1½ |
| 317 | 3 | 2 | 3 | 4 | 2 | 1½ | 2 | 1½ | 1½ | 0 |
| 319 | 1 | ½ | ½ | 1 | 0 | 0 | 0 | 0 | 0 | ½ |
| 321 | 2 | 2 | 1½ | 2 | 2½ | 3 | 0 | 0 | 1½ | 1½ |
| Total....... | 26½ | 20½ | 14 | 18½ | 15½ | 15½ | 11 | 10 | 11 | 9½ |
| Mean....... | 1.6 | 1.2 | .8 | 1.1 | .9 | .9 | .7 | .6 | .7 | .6 |
| Sigma$_M$.... | .18 | .19 | .20 | .22 | .21 | .23 | .17 | .13 | .14 | .16 |
| Median..... | 1.8 | 1.4 | .9 | 1.3 | 1.1 | .9 | .7 | .8 | .8 | .6 |

## APPENDIX 4

*Response amplitude in mm.*

| RAT NO. | CS-HABITUATION GROUP DAYS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 10 | 3½ | 5½ | 4 | 4 | 6½ | 0 | 3 | ½ | ½ |
| 21 | 15½ | 7 | 23 | 10 | 11½ | 6½ | 13 | 9 | 6½ | 6 |
| 23 | 21 | 17½ | 15 | 11½ | 12 | 12 | 6½ | 1½ | 7½ | 7½ |
| 47 | 33½ | 11½ | 8½ | 8½ | 4½ | 5 | 4½ | 3½ | 8 | 7 |
| 49 | 46 | 35 | 22½ | 9½ | 12½ | 2 | 2 | 5 | 2 | 2 |
| 73 | 4 | 13 | 4½ | 3½ | 4 | 9½ | 8 | 6 | 5½ | 1½ |
| 87 | 3½ | 7½ | 4 | 1½ | 6 | 5½ | 7½ | 8 | 0 | 0 |
| 101 | 14 | 9½ | 7 | 12 | 11 | 6½ | 12 | 17 | 6 | 7½ |
| 119 | 6½ | 7½ | 11½ | 3½ | 2 | 7½ | 4½ | 0 | 2½ | 1 |
| 132 | 4½ | 9 | 6½ | 5½ | 8 | 10 | 9½ | 12 | 10½ | 5 |
| 135 | 6½ | 4½ | 5 | 4 | 7 | 9½ | 9 | 7 | 1½ | 9 |
| 138 | 13 | 30 | 11½ | 9 | 13 | 12½ | 11½ | 11 | 14 | 9 |
| 140 | 7 | 7 | 5 | 5 | 5½ | 6½ | 1½ | 0 | 1 | 0 |
| 142 | 21 | 9 | 12½ | 17½ | 10½ | 14 | 12 | 8 | 7½ | 4 |
| 144 | 2½ | 2 | 3½ | 1½ | 1 | 3 | 1½ | 1 | 2 | 5 |
| 158 | 16½ | 20 | 8½ | 12 | 7 | 1½ | 13½ | 6 | 5 | 5 |
| 178 | 40½ | 22 | 20 | 28 | 16 | 11 | 3 | ½ | 2 | 1½ |
| 180 | 29½ | 17 | 27 | 11 | 9½ | 24½ | 12 | 15½ | 14½ | 16 |
| 187 | 30½ | 24½ | 15 | 14 | 17 | 13 | 22½ | 12 | 6 | 5 |
| 193 | 40½ | 9½ | 8 | 13½ | 10½ | 13 | 24 | 17½ | 23 | 17 |
| 195 | 13 | 12 | 6 | 10 | 4½ | 9 | 14 | 18 | 8 | 14½ |
| 201 | 49½ | 27 | 21½ | 23 | 13½ | 14½ | 13½ | 11 | 10 | 10 |
| 205 | 25½ | 19½ | 9½ | 12 | 15½ | 9½ | 5 | 2 | 5 | 5 |
| 219 | 33 | 23 | 18 | 20 | 9 | 9 | 9 | 11 | 11½ | 14½ |
| 221 | 31½ | 15½ | 10 | 14½ | 16 | 15 | 14½ | 9 | 4½ | 8½ |
| 226 | 21 | 16 | 13 | 13 | 13½ | 1 | 5½ | 7 | 6 | 11 |
| 233 | 23 | 14½ | 20½ | 21 | 18 | 11½ | 4½ | 16 | 11 | 11 |
| 243 | 24½ | 17 | 9½ | 13½ | 15 | 7 | 6 | 4 | 6 | 2½ |
| 249 | 26 | 21 | 16 | 20 | 12½ | 15 | 15 | 17 | 17 | 10 |
| 250 | 42½ | 22 | 10½ | 13½ | 15½ | 6 | 13½ | 12 | 5½ | 11½ |
| 251 | 16½ | 15½ | 24½ | 19½ | 13 | 8½ | 9 | 10 | 12 | 7 |
| 260 | 24½ | 18 | 6½ | 13½ | 6½ | 9 | 14½ | 11 | 7 | 5½ |
| 263 | 13 | 13 | 19 | 1½ | 4½ | 8 | 4½ | 3½ | 12½ | 9 |
| 267 | 27 | 17 | 22½ | 8 | 7 | 11½ | 15 | 10½ | 15 | 10 |
| Total....... | 736½ | 517½ | 431 | 388 | 336½ | 314 | 321½ | 285½ | 256½ | 239½ |
| Mean....... | 21.6 | 15.2 | 12.6 | 11.4 | 9.9 | 9.2 | 9.4 | 8.4 | 7.5 | 7.0 |
| Sigma$_M$..... | 2.03 | 1.41 | 1.12 | 1.13 | .93 | .75 | .95 | .93 | .85 | .67 |
| Median..... | 21.6 | 15.5 | 11.6 | 11.3 | 10.4 | 8.8 | 9.0 | 8.5 | 7.8 | 7.7 |

## APPENDIX 5

*Response amplitude in mm.*

| RAT NO. | RANDOM-ORDER GROUP DAYS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 3 | | 5 | 6 | 7 | 8 | 9 | 10 |
| 3 | 23 | 9 | 9½ | 12½ | 13 | 8 | 9½ | 14½ | 10 | 13 |
| 6 | 15 | 11 | 17 | 14 | 11 | 14½ | 9 | 14 | 15 | 13 |
| 51 | 22 | 13½ | 10½ | 12 | 5½ | 6½ | 12½ | 13½ | 14½ | 9½ |
| 74 | 18½ | 28 | 20½ | 13 | 16½ | 18 | 22½ | 19 | 13½ | 14 |
| 89 | 16½ | 15 | 13 | 11 | 11 | 13 | 14 | 13 | 12½ | 15½ |
| 122 | 21 | 14½ | 18 | 15½ | 11½ | 14 | 14½ | 12 | 8 | 6½ |
| 133 | 15 | 17 | 18 | 13½ | 13½ | 16 | 7 | 16½ | 7 | 12 |
| 140 | 19 | 14 | 11½ | 19 | 7 | 14½ | 3 | 7 | 11 | 17 |
| 141 | 12½ | 13½ | 14½ | 15½ | 12½ | 15½ | 6½ | 7½ | 13 | 12½ |
| 156 | 31 | 19½ | 18 | 18½ | 27 | 16½ | 24 | 11½ | 8 | 17 |
| 179 | 27 | 22 | 22½ | 20 | 27 | 15½ | 14 | 22 | 19 | 17½ |
| 190 | 20½ | 28 | 19½ | 13 | 8 | 23½ | 10 | 11½ | 10 | 17 |
| 208 | 31 | 23 | 26 | 19½ | 28 | 18½ | 13½ | 11 | 19 | 31½ |
| 216 | 12 | 26 | 37½ | 32 | 17 | 14 | 18½ | 16 | 20 | 13 |
| 247 | 16½ | 16 | 17 | 29 | 29½ | 14½ | 16½ | 22½ | 18½ | 13 |
| 261 | 29 | 29 | 23 | 15½ | 7 | 13 | 6½ | 13 | 10 | 8 |
| 265 | 15½ | 30 | 25 | 26½ | 27 | 8 | 17½ | 8 | 12½ | 10 |
| Total....... | 345 | 329 | 321 | 300 | 272 | 243½ | 219 | 232½ | 221½ | 240 |
| Mean....... | 20.2 | 19.3 | 18.8 | 17.6 | 16.0 | 14.3 | 12.8 | 13.7 | 13.0 | 14.1 |
| Sigma$_M$..... | 1.42 | 1.71 | 1.72 | 1.46 | 1.86 | 1.00 | 1.21 | 1.05 | .94 | 1.67 |
| Median..... | 19.6 | 18.1 | 17.9 | 16.2 | 14.6 | 13.9 | 12.0 | 13.0 | 13.0 | 13.4 |

## APPENDIX 6
*Response amplitude in mm.*

| RAT NO. | CONDITIONING GROUP DAYS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 14 | 10 | 20 | 24 | 23 | $25\frac{1}{2}$ | $22\frac{1}{2}$ | 23 | $23\frac{1}{2}$ | 28 |
| 26 | $5\frac{1}{2}$ | 42 | $17\frac{1}{2}$ | $22\frac{1}{2}$ | 24 | $47\frac{1}{2}$ | $39\frac{1}{2}$ | $24\frac{1}{2}$ | $38\frac{1}{2}$ | $35\frac{1}{2}$ |
| 50 | $34\frac{1}{2}$ | 22 | 21 | $17\frac{1}{2}$ | 21 | $21\frac{1}{2}$ | 28 | 21 | 23 | 22 |
| 52 | $35\frac{1}{2}$ | $12\frac{1}{2}$ | 26 | 19 | 19 | 20 | $23\frac{1}{2}$ | $25\frac{1}{2}$ | $22\frac{1}{2}$ | $32\frac{1}{2}$ |
| 60 | 15 | 20 | $12\frac{1}{2}$ | $19\frac{1}{2}$ | $28\frac{1}{2}$ | 22 | $23\frac{1}{2}$ | $26\frac{1}{2}$ | 26 | $24\frac{1}{2}$ |
| 79 | 9 | $16\frac{1}{2}$ | 16 | $19\frac{1}{2}$ | $23\frac{1}{2}$ | 23 | $20\frac{1}{2}$ | $19\frac{1}{2}$ | 23 | $13\frac{1}{2}$ |
| 116 | 14 | 20 | $22\frac{1}{2}$ | $24\frac{1}{2}$ | $24\frac{1}{2}$ | 24 | 20 | 24 | 26 | 30 |
| 143 | 22 | 12 | 19 | $19\frac{1}{2}$ | 21 | 24 | $11\frac{1}{2}$ | 21 | $19\frac{1}{2}$ | $21\frac{1}{2}$ |
| 149 | $8\frac{1}{2}$ | $21\frac{1}{2}$ | $16\frac{1}{2}$ | 23 | 24 | 24 | 23 | $21\frac{1}{2}$ | 29 | 27 |
| 155 | 13 | 11 | 10 | 17 | 17 | 17 | $15\frac{1}{2}$ | 24 | $23\frac{1}{2}$ | $24\frac{1}{2}$ |
| 174 | $18\frac{1}{2}$ | $14\frac{1}{2}$ | $21\frac{1}{2}$ | 26 | 23 | $18\frac{1}{2}$ | $26\frac{1}{2}$ | $25\frac{1}{2}$ | $21\frac{1}{2}$ | 28 |
| 177 | 10 | $11\frac{1}{2}$ | $18\frac{1}{2}$ | 39 | 24 | $21\frac{1}{2}$ | 24 | 26 | $25\frac{1}{2}$ | $22\frac{1}{2}$ |
| 183 | $38\frac{1}{2}$ | 37 | 20 | 27 | 36 | 21 | 32 | 39 | $32\frac{1}{2}$ | $33\frac{1}{2}$ |
| 188 | 14 | 19 | 17 | $18\frac{1}{2}$ | 19 | 22 | 30 | 24 | $26\frac{1}{2}$ | $29\frac{1}{2}$ |
| 194 | $9\frac{1}{2}$ | 11 | 10 | 25 | 19 | $21\frac{1}{2}$ | 26 | $29\frac{1}{2}$ | $17\frac{1}{2}$ | $30\frac{1}{2}$ |
| 196 | 35 | 24 | $41\frac{1}{2}$ | $31\frac{1}{2}$ | 43 | 36 | $50\frac{1}{2}$ | $27\frac{1}{2}$ | $22\frac{1}{2}$ | $30\frac{1}{2}$ |
| 204 | $6\frac{1}{2}$ | 18 | $32\frac{1}{2}$ | 30 | $21\frac{1}{2}$ | $32\frac{1}{2}$ | 33 | $35\frac{1}{2}$ | $38\frac{1}{2}$ | $28\frac{1}{2}$ |
| 214 | $35\frac{1}{2}$ | $32\frac{1}{2}$ | 30 | $16\frac{1}{2}$ | $45\frac{1}{2}$ | 35 | 16 | 39 | $38\frac{1}{2}$ | 40 |
| 220 | 15 | 60 | $52\frac{1}{2}$ | 34 | 41 | $21\frac{1}{2}$ | 19 | 30 | 24 | 27 |
| 227 | $8\frac{1}{2}$ | $15\frac{1}{2}$ | 52 | $33\frac{1}{2}$ | $30\frac{1}{2}$ | 18 | $18\frac{1}{2}$ | $24\frac{1}{2}$ | $18\frac{1}{2}$ | $17\frac{1}{2}$ |
| 246 | $8\frac{1}{2}$ | $12\frac{1}{2}$ | 19 | $24\frac{1}{2}$ | $22\frac{1}{2}$ | $24\frac{1}{2}$ | 28 | $19\frac{1}{2}$ | 36 | 22 |
| 259 | $16\frac{1}{2}$ | $19\frac{1}{2}$ | $16\frac{1}{2}$ | 30 | $17\frac{1}{2}$ | 30 | $27\frac{1}{2}$ | 19 | 34 | $21\frac{1}{2}$ |
| 264 | $24\frac{1}{2}$ | $13\frac{1}{2}$ | $35\frac{1}{2}$ | 39 | 37 | 37 | $36\frac{1}{2}$ | 45 | 33 | $43\frac{1}{2}$ |
| 268 | 28 | $15\frac{1}{2}$ | $21\frac{1}{2}$ | $19\frac{1}{2}$ | $22\frac{1}{2}$ | 31 | $27\frac{1}{2}$ | $18\frac{1}{2}$ | 32 | 40 |
| Total....... | $439\frac{1}{2}$ | $491\frac{1}{2}$ | 569 | 600 | $627\frac{1}{2}$ | $618\frac{1}{2}$ | $622\frac{1}{2}$ | 633 | 655 | $673\frac{1}{2}$ |
| Mean....... | 17.6 | 20.4 | 23.6 | 25.0 | 25.3 | 25.7 | 25.9 | 26.3 | 27.2 | 28.0 |
| Sigma$_M$..... | 2.19 | 2.24 | 2.33 | 1.46 | 1.77 | 1.32 | 1.29 | 1.42 | 1.36 | 1.16 |
| Median..... | 14.9 | 17.5 | 20.8 | 23.0 | 22.9 | 23.4 | 24.9 | 24.4 | 26.0 | 27.5 |

## APPENDIX 7

*Response amplitude in mm.*

| RAT NO. | RANDON-ORDER GROUP TRIALS DURING FIRST "EXTINCTION" | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | $\frac{1}{2}$ | 0 | $1\frac{1}{2}$ | $\frac{1}{2}$ | 0 | 0 | 0 | 0 | $\frac{1}{2}$ | 0 |
| 51 | $\frac{1}{2}$ | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 74 | 1 | 2 | $1\frac{1}{2}$ | 2 | 2 | $1\frac{1}{2}$ | 3 | 1 | 2 | $\frac{1}{2}$ |
| 89 | 1 | 1 | 0 | 0 | $\frac{1}{2}$ | 1 | 0 | $\frac{1}{2}$ | 0 | 0 |
| 122 | 0 | 0 | $\frac{1}{2}$ | 0 | 0 | 0 | 0 | $\frac{1}{2}$ | 1 | 0 |
| 133 | $\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 1 | 1 | $1\frac{1}{2}$ | 1 | 1 | 2 | 2 |
| 140 | 1 | $\frac{1}{2}$ | 0 | $\frac{1}{2}$ | 0 | $1\frac{1}{2}$ | 2 | 2 | 3 | $\frac{1}{2}$ |
| 141 | 0 | $\frac{1}{2}$ | 1 | 0 | 0 | $\frac{1}{2}$ | 1 | 0 | 0 | 0 |
| 156 | $1\frac{1}{2}$ | 3 | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 2 |
| 179 | 10 | $2\frac{1}{2}$ | 4 | $3\frac{1}{2}$ | 1 | 3 | 3 | $2\frac{1}{2}$ | 2 | $2\frac{1}{2}$ |
| 190 | $1\frac{1}{2}$ | $7\frac{1}{2}$ | 2 | $2\frac{1}{2}$ | $4\frac{1}{2}$ | $\frac{1}{2}$ | 0 | 9 | 4 | 4 |
| 208 | 5 | 5 | 5 | 4 | $1\frac{1}{2}$ | $2\frac{1}{2}$ | 1 | $2\frac{1}{2}$ | $2\frac{1}{2}$ | 1 |
| 216 | 2 | 4 | 4 | $3\frac{1}{2}$ | 4 | $2\frac{1}{2}$ | 2 | 1 | 1 | 8 |
| 247 | 0 | 0 | 4 | $2\frac{1}{2}$ | 1 | 4 | $4\frac{1}{2}$ | $\frac{1}{2}$ | 3 | 5 |
| 261 | $2\frac{1}{2}$ | 3 | 0 | 0 | 0 | $\frac{1}{2}$ | 0 | 0 | 0 | 0 |
| 265 | 2 | $\frac{1}{2}$ | 2 | 1 | 1 | 2 | $3\frac{1}{2}$ | 2 | 2 | 3 |
| Total....... | 30 | 32 | 29 | 23 | $17\frac{1}{2}$ | 22 | 22 | $25\frac{1}{2}$ | 24 | $28\frac{1}{2}$ |
| Mean....... | 1.7 | 1.8 | 1.7 | 1.3 | 1.0 | 1.3 | 1.3 | 1.5 | 1.7 | 1.6 |
| Sigma$_M$..... | .58 | .49 | .39 | .31 | .30 | .28 | .31 | .54 | .29 | .46 |
| Median..... | 1.4 | 1.5 | 1.6 | 1.2 | 1.0 | 1.3 | 1.3 | 1.1 | 1.8 | .9 |

## APPENDIX 8

*Response amplitude in mm.*

| RAT NO. | CS-HABITUATION GROUP TRIALS DURING FIRST "EXTINCTION" | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ |
| 49 | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 73 | 1 | $\frac{1}{2}$ | 1 | $\frac{1}{2}$ | 0 | 0 | 0 | 1 | 1 | 0 |
| 87 | $\frac{1}{2}$ | $\frac{1}{2}$ | 1 | 0 | $\frac{1}{2}$ | 0 | 1 | 1 | $\frac{1}{2}$ | 0 |
| 119 | $\frac{1}{2}$ | $\frac{1}{2}$ | 0 | 0 | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ |
| 132 | 1 | 0 | $\frac{1}{2}$ | $\frac{1}{2}$ | 1 | 1 | $\frac{1}{2}$ | $\frac{1}{2}$ | $1\frac{1}{2}$ | 0 |
| 138 | $1\frac{1}{2}$ | 1 | 0 | $\frac{1}{2}$ | 0 | 0 | $1\frac{1}{2}$ | 0 | 2 | 1 |
| 140 | $\frac{1}{2}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 178 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | $3\frac{1}{2}$ |
| 195 | 0 | 0 | 0 | 1 | 1 | 1 | $1\frac{1}{2}$ | 1 | 1 | $1\frac{1}{2}$ |
| 205 | $\frac{1}{2}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | $\frac{1}{2}$ | 0 |
| 226 | 2 | 0 | 1 | $\frac{1}{2}$ | 0 | 0 | 2 | 0 | $\frac{1}{2}$ | 1 |
| 243 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | $2\frac{1}{2}$ | 0 |
| 250 | 0 | 0 | $1\frac{1}{2}$ | $\frac{1}{2}$ | $1\frac{1}{2}$ | 0 | 0 | 0 | $1\frac{1}{2}$ | 1 |
| Total...... | 8 | 3 | $5\frac{1}{2}$ | $4\frac{1}{2}$ | $5\frac{1}{2}$ | $3\frac{1}{2}$ | 7 | $4\frac{1}{2}$ | 13 | 9 |
| Mean....... | .5 | .2 | .4 | .3 | .4 | .2 | .5 | .3 | .8 | .6 |
| Sigma$_M$..... | .14 | .07 | .13 | .09 | .13 | .10 | .17 | .10 | .18 | .24 |
| Median..... | .6 | .3 | .4 | .4 | .4 | .3 | .4 | .4 | .9 | .4 |

## APPENDIX 9

*Random-order group*

*"Extinction" trials, second and third series*

| RAT NO. | TIME AFTER FIRST "EXTINCTION" SERIES | |
|---|---|---|
| | 24 hrs. | 48 hrs. |
| 3 | 2 | 3 |
| 6 | $1\frac{1}{2}$ | $5\frac{1}{2}$ |
| 51 | 1 | $\frac{1}{2}$ |
| 74 | $4\frac{1}{2}$ | 2 |
| 89 | 2 | 2 |
| 122 | 2 | 1 |
| 133 | 1 | $2\frac{1}{2}$ |
| 140 | 1 | 1 |
| 141 | 4 | $1\frac{1}{2}$ |
| 156 | $1\frac{1}{2}$ | $3\frac{1}{2}$ |
| 179 | 6 | 2 |
| 190 | 2 | 2 |
| 208 | $1\frac{1}{2}$ | $2\frac{1}{2}$ |
| 216 | 5 | $4\frac{1}{2}$ |
| 247 | $6\frac{1}{2}$ | 3 |
| 261 | 1 | 0 |
| 265 | 5 | 0 |
| Total................. | $47\frac{1}{2}$ | $36\frac{1}{2}$ |
| Mean amplitude per trial.......... | .3 | .2 |
| SigmaMn............... | .04 | .03 |
| Median amplitude per trial.......... | .3 | .2 |

## APPENDIX 10

*CS-habituation group*

*"Extinction" trials, second and third series*

| RAT NO. | TIME AFTER FIRST "EXTINCTION" SERIES | |
|---|---|---|
| | 24 hrs. | 48 hrs. |
| 2 | 0 | 0 |
| 23 | $3\frac{1}{2}$ | 2 |
| 49 | 8 | 3 |
| 73 | 4 | $7\frac{1}{2}$ |
| 87 | 6 | 4 |
| 119 | $1\frac{1}{2}$ | 3 |
| 132 | 2 | 8 |
| 138 | 3 | 2 |
| 140 | 0 | 1 |
| 178 | $6\frac{1}{2}$ | 4 |
| 187 | 3 | 0 |
| 195 | $6\frac{1}{2}$ | 2 |
| 205 | 8 | 6 |
| 226 | $8\frac{1}{2}$ | 3 |
| 243 | $5\frac{1}{2}$ | 1 |
| 250 | 10 | 4 |
| Total................. | 76 | $50\frac{1}{2}$ |
| Mean amplitude per trial......... | .4 | .3 |
| SigmaMn........... | .06 | .05 |
| Median amplitude per trial......... | .5 | .3 |

## APPENDIX 11
### *Response amplitude in mm.*

| RAT NO. | PSEUDO-CONDITIONING GROUP TRIALS DURING FIRST "EXTINCTION" | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 83 | 9 | 5 | 2 | 4 | $1\frac{1}{2}$ | 1 | $\frac{1}{2}$ | 1 | 1 | 1 |
| 118 | $8\frac{1}{2}$ | 4 | 1 | 7 | 1 | 2 | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 1 |
| 129 | 2 | 4 | $1\frac{1}{2}$ | 1 | 1 | $\frac{1}{2}$ | 0 | 0 | 0 | $\frac{1}{2}$ |
| 169 | 7 | 2 | 2 | $5\frac{1}{2}$ | $5\frac{1}{2}$ | 4 | $\frac{1}{2}$ | 2 | 1 | $\frac{1}{2}$ |
| 176 | 11 | $6\frac{1}{2}$ | 3 | 4 | 3 | $1\frac{1}{2}$ | 7 | $\frac{1}{2}$ | 1 | 3 |
| 302 | 4 | $4\frac{1}{2}$ | $1\frac{1}{2}$ | 1 | 2 | $1\frac{1}{2}$ | $2\frac{1}{2}$ | $\frac{1}{2}$ | 1 | $1\frac{1}{2}$ |
| 304 | $2\frac{1}{2}$ | $2\frac{1}{2}$ | 2 | 2 | 2 | $2\frac{1}{2}$ | $1\frac{1}{2}$ | 1 | 1 | 2 |
| 306 | 3 | 2 | 1 | 2 | 3 | 3 | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 2 | $2\frac{1}{2}$ |
| 308 | 4 | 3 | 2 | 3 | $2\frac{1}{2}$ | 2 | 3 | 3 | $2\frac{1}{2}$ | 1 |
| 310 | 8 | $2\frac{1}{2}$ | 3 | $2\frac{1}{2}$ | 3 | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $2\frac{1}{2}$ | 1 | $\frac{1}{2}$ |
| 312 | 8 | 8 | 3 | 4 | $2\frac{1}{2}$ | 6 | 1 | 2 | 2 | 2 |
| 314 | 2 | $4\frac{1}{2}$ | $2\frac{1}{2}$ | $\frac{1}{2}$ | 1 | $\frac{1}{2}$ | 2 | $2\frac{1}{2}$ | 1 | $1\frac{1}{2}$ |
| 318 | 8 | $3\frac{1}{2}$ | $1\frac{1}{2}$ | $\frac{1}{2}$ | 2 | 3 | $2\frac{1}{2}$ | 3 | 4 | $3\frac{1}{2}$ |
| 320 | 6 | $4\frac{1}{2}$ | 0 | 0 | 0 | $1\frac{1}{2}$ | 0 | 0 | $1\frac{1}{2}$ | 1 |
| 322 | 5 | $2\frac{1}{2}$ | 2 | 2 | 3 | $2\frac{1}{2}$ | $2\frac{1}{2}$ | 1 | 3 | 4 |
| Total....... | 88 | 59 | 28 | 39 | 33 | 33 | $27\frac{1}{2}$ | 22 | $23\frac{1}{2}$ | $25\frac{1}{2}$ |
| Mean....... | 5.8 | 3.8 | 1.8 | 2.6 | 2.2 | 2.2 | 1.8 | 1.4 | 1.5 | 1.7 |
| Sigma$_M$..... | .70 | .45 | .22 | .51 | .31 | .30 | .37 | .26 | .25 | .30 |
| Median..... | 6.5 | 4.1 | 2.3 | 2.6 | 2.6 | 2.1 | 1.7 | 1.7 | 1.7 | 1.7 |

## APPENDIX 12

*Response amplitude in mm.*

| RAT NO. | CONDITIONING GROUP TRIALS DURING FIRST EXTINCTION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 0 | ½ | 0 | 0 | ½ | 1 | 1½ | 3 | 5 | 1 |
| 26 | 5 | 8½ | 4 | ½ | ½ | ½ | 1 | 1 | 1 | 2 |
| 50 | 1 | 2 | 4 | 5½ | 1 | 3½ | ½ | 0 | 0 | 0 |
| 52 | 2½ | 6 | 4 | 3 | 2 | ½ | ½ | 0 | 0 | ½ |
| 60 | 3½ | 4 | 3 | 3 | 1 | 0 | ½ | ½ | ½ | 2½ |
| 79 | 2½ | 2 | 2 | 2½ | ½ | 1 | 2 | 1 | ½ | 2 |
| 116 | 1½ | 1 | 1 | 1 | 2½ | 1 | 1 | 1 | 1 | ½ |
| 143 | 4 | ½ | ½ | 0 | 0 | 0 | 0 | 0 | 5 | 3½ |
| 149 | 1 | 1 | 1½ | ½ | 1½ | 1 | 0 | 0 | 0 | 1½ |
| 155 | ½ | ½ | 3 | 3½ | 0 | 0 | 0 | 0 | 0 | ½ |
| 174 | 2 | 1 | ½ | ½ | 0 | 1 | 0 | ½ | ½ | 0 |
| 177 | ½ | 2 | 4 | 4 | 1 | 4 | 1½ | 6½ | 3 | 3 |
| 183 | 7 | 4½ | 4 | 2 | 3 | 2 | 6 | 1½ | 5 | 3 |
| 188 | 2½ | 3 | 2½ | 3½ | 2 | 2 | 1 | 1½ | 3½ | 4 |
| 194 | 5½ | 2½ | 4½ | 4½ | 5 | 2 | 3 | 3 | 2½ | 6½ |
| 196 | 1 | 7 | 8 | 3½ | 6 | 8 | 1 | 1½ | 2 | 1½ |
| 204 | 4 | 2½ | 2 | 2½ | 4 | ½ | ½ | 1 | 3½ | 1 |
| 214 | 1 | ½ | ½ | 1 | 0 | 0 | 1 | 0 | 0 | ½ |
| 220 | 9 | 3 | 8 | 4½ | 3½ | 1½ | 1 | 3 | 0 | 1 |
| 227 | 1 | 1½ | 5 | 5 | 4½ | 6½ | 4 | 6 | 4 | 3 |
| 246 | 2½ | 3 | 3 | 1½ | 3 | 5 | 4 | 2½ | 3 | 2½ |
| 259 | ½ | 3 | 8 | 1 | 5 | 5 | 5½ | 4½ | 0 | 1½ |
| 264 | 4½ | 2 | 5½ | 2½ | 2½ | 3½ | 5 | 3 | 5 | 3 |
| 268 | 3 | 7 | 4½ | 3 | 1 | 1 | 3 | ½ | 1½ | ½ |
| Total....... | 65½ | 68½ | 83 | 58½ | 50 | 48½ | 43½ | 41½ | 46½ | 46 |
| Mean....... | 2.7 | 2.8 | 3.4 | 2.4 | 2.0 | 2.0 | 1.8 | 1.6 | 1.9 | 1.9 |
| Sigma$_M$..... | .43 | .47 | .49 | .34 | .36 | .40 | .37 | .36 | .38 | .32 |
| Median..... | 2.6 | 2.8 | 3.9 | 2.7 | 1.9 | 1.6 | 1.5 | 1.4 | 1.6 | 1.8 |

## APPENDIX 13

*Conditioning group*

*Extinction trials, second and third series*

| RAT NO. | TIME AFTER FIRST EXTINCTION SERIES | |
|---|---|---|
| | 24 hrs. | 48 hrs. |
| 1 | $6\frac{1}{2}$ | 0 |
| 26 | 0 | $\frac{1}{2}$ |
| 50 | $3\frac{1}{2}$ | 8 |
| 52 | 11 | 3 |
| 60 | $18\frac{1}{2}$ | $17\frac{1}{2}$ |
| 79 | 19 | 10 |
| 116 | $4\frac{1}{2}$ | 1 |
| 143 | 0 | 0 |
| 149 | $5\frac{1}{2}$ | $3\frac{1}{2}$ |
| 155 | 12 | 0 |
| 174 | 3 | 1 |
| 177 | $11\frac{1}{2}$ | 4 |
| 183 | 11 | $6\frac{1}{2}$ |
| 188 | $14\frac{1}{2}$ | 11 |
| 194 | $13\frac{1}{2}$ | 6 |
| 196 | 4 | $21\frac{1}{2}$ |
| 204 | 10 | 19 |
| 214 | 2 | 0 |
| 220 | $27\frac{1}{2}$ | 21 |
| 227 | $\frac{1}{2}$ | $\frac{1}{2}$ |
| 246 | 5 | $1\frac{1}{2}$ |
| 259 | 4 | $6\frac{1}{2}$ |
| 264 | $21\frac{1}{2}$ | $12\frac{1}{2}$ |
| 268 | 3 | 1 |
| Total...................... | $201\frac{1}{2}$ | $155\frac{1}{2}$ |
| Mean Amplitude per Trial... | .8 | .6 |
| Sigma$_{Mn}$................. | .14 | .13 |
| Median Amplitude per Trial. | .8 | .4 |

## APPENDIX 14

*Response amplitude in mm.*

| RAT NO. | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | PRE-SOUND GROUP DAYS | | | | | |
| 21a | 14 | 18 | 23 | 29 | 30½ | 16 | 27 | 14 | 27 | 17 |
| 47 | 13 | 12½ | 18 | 12½ | 21 | 26½ | 12 | 21 | 29 | 36½ |
| 101 | 13½ | 10½ | 12 | 15 | 15 | 23 | 26 | 25½ | 15½ | 21 |
| 135 | 10½ | 15 | 15½ | 15 | 22 | 22 | 29½ | 25½ | 27½ | 21½ |
| 142 | 13½ | 17 | 20 | 10 | 12 | 13 | 13½ | 29½ | 17½ | 23½ |
| 144 | 4½ | 8½ | 13½ | 10½ | 19 | 11 | 21 | 25 | 18½ | 22 |
| 158 | 5½ | 11½ | 20½ | 14½ | 18½ | 21 | 20 | 22½ | 7½ | 12 |
| 180a | 19 | 16½ | 18½ | 18 | 27 | 18½ | 32½ | 27 | 26½ | 29½ |
| 193 | 12 | 14 | 5½ | 19 | 13½ | 23½ | 21 | 22½ | 29½ | 33½ |
| 201 | 5 | 13 | 21½ | 27½ | 27½ | 35 | 28½ | 20 | 27 | 30½ |
| 219 | 10½ | 20½ | 21½ | 24½ | 16 | 11 | 11½ | 20½ | 20½ | 18½ |
| 221 | 14½ | 15 | 12½ | 12½ | 16½ | 16 | 14 | 16½ | 22 | 22½ |
| 233 | 8½ | 16 | 12½ | 24 | 13½ | 20½ | 13 | 24 | 18½ | 18 |
| 249 | 15½ | 8 | 21 | 15½ | 13½ | 16 | 17½ | 20½ | 15 | 19 |
| 251 | 8 | 13 | 16 | 14 | 14 | 11½ | 19 | 17½ | 17½ | 24½ |
| 260 | 23½ | 16 | 14½ | 17½ | 15 | 28 | 20 | 20 | 23½ | 25½ |
| 263 | 20½ | 12 | 14½ | 21 | 39 | 37 | 25 | 14 | 14 | 17½ |
| 267 | 13 | 21 | 23½ | 21 | 25 | 20 | 13½ | 23 | 29 | 21½ |
| Total....... | 244½ | 258 | 304 | 321 | 358½ | 369½ | 364½ | 388½ | 385½ | 414 |
| Mean....... | 12.4 | 14.3 | 16.8 | 17.8 | 19.9 | 20.5 | 20.2 | 21.5 | 21.4 | 23.0 |
| Sigma$_M$..... | 1.17 | 1.04 | .97 | 1.16 | 1.72 | 1.70 | 1.58 | 1.06 | 1.32 | 1.46 |
| Median..... | 11.5 | 13.7 | 14.9 | 17.5 | 18.3 | 20.8 | 21.2 | 22.5 | 21.6 | 22.4 |

## APPENDIX 15

*Response amplitude in mm.*

| RAT NO. | PRE-SOUND GROUP TRIALS DURING FIRST EXTINCTION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 21a | 5 | 5 | 5 | 7 | 1 | 4 | $6\frac{1}{2}$ | 6 | 2 | 4 |
| 47 | 1 | 4 | 6 | 3 | 3 | $2\frac{1}{2}$ | $4\frac{1}{2}$ | 1 | 0 | 5 |
| 135 | 2 | 2 | 3 | 6 | 0 | 3 | $1\frac{1}{2}$ | 1 | 0 | 0 |
| 142 | 1 | 1 | 2 | 0 | $7\frac{1}{2}$ | 5 | 0 | 0 | 0 | 1 |
| 144 | 2 | 2 | 2 | 3 | 0 | $1\frac{1}{2}$ | 0 | 3 | 0 | 0 |
| 158 | $1\frac{1}{2}$ | 0 | 0 | $\frac{1}{2}$ | 0 | 0 | $2\frac{1}{2}$ | $\frac{1}{2}$ | 0 | 0 |
| 180 | 3 | $2\frac{1}{2}$ | 2 | $\frac{1}{2}$ | 1 | $3\frac{1}{2}$ | $1\frac{1}{2}$ | $\frac{1}{2}$ | 6 | $3\frac{1}{2}$ |
| 193 | $2\frac{1}{2}$ | $2\frac{1}{2}$ | 2 | 5 | 5 | 4 | 3 | 3 | $4\frac{1}{2}$ | $1\frac{1}{2}$ |
| 201 | 7 | 4 | 2 | $4\frac{1}{2}$ | 5 | 3· | 5 | $4\frac{1}{2}$ | 5 | 5 |
| 219 | $2\frac{1}{2}$ | $6\frac{1}{2}$ | 4 | 2 | 3 | 2 | 2 | $2\frac{1}{2}$ | 3 | $2\frac{1}{2}$ |
| 221 | $1\frac{1}{2}$ | 1 | 2 | 1 | 2 | $\frac{1}{2}$ | 1 | 2 | $1\frac{1}{2}$ | 0 |
| 233 | $4\frac{1}{2}$ | 2 | 2 | 0 | 2 | 1 | $2\frac{1}{2}$ | $\frac{1}{2}$ | 0 | 0 |
| 249 | $4\frac{1}{2}$ | 6 | $1\frac{1}{2}$ | 3 | 1 | $1\frac{1}{2}$ | 0 | 0 | 3 | 2 |
| 251 | 1 | 0 | 0 | 0 | $\frac{1}{2}$ | 0 | 0 | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ |
| 260 | 2 | $4\frac{1}{2}$ | 0 | 2 | 2 | 2 | 3 | $3\frac{1}{2}$ | $1\frac{1}{2}$ | 4 |
| 263 | $\frac{1}{2}$ | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 267 | 1 | 1 | $2\frac{1}{2}$ | 1 | $1\frac{1}{2}$ | 1 | 1 | 0 | $1\frac{1}{2}$ | $2\frac{1}{2}$ |
| Total....... | $42\frac{1}{2}$ | 44 | 36 | $38\frac{1}{2}$ | $34\frac{1}{2}$ | $34\frac{1}{2}$ | 35 | $28\frac{1}{2}$ | $28\frac{1}{2}$ | $30\frac{1}{2}$ |
| Mean....... | 2.5 | 2.6 | 2.1 | 2.2 | 2.0 | 2.0 | 2.0 | 1.6 | 1.6 | 1.7 |
| Sigma$_M$..... | .41 | .46 | .41 | .54 | .48 | .38 | .42 | .42 | .47 | .41 |
| Median..... | 2.3 | 2.5 | 2.3 | 2.2 | 1.8 | 2.1 | 1.9 | 1.2 | 1.1 | 1.7 |

### APPENDIX 16

*Pre-sound group*
*Extinction trials second and third series*

| RAT NO. | TIME AFTER FIRST EXTINCTION SERIES | |
| --- | --- | --- |
| | 24 hrs. | 48 hrs. |
| 21 | $14\frac{1}{2}$ | 5 |
| 47 | 17 | 2 |
| 101 | 14 | 8 |
| 135 | 10 | 6 |
| 142 | 6 | 4 |
| 144 | 18 | 10 |
| 158 | 4 | $3\frac{1}{2}$ |
| 180 | $9\frac{1}{2}$ | $13\frac{1}{2}$ |
| 193 | 6 | 2 |
| 201 | $4\frac{1}{2}$ | $11\frac{1}{2}$ |
| 219 | $3\frac{1}{2}$ | 2 |
| 221 | 8 | 2 |
| 233 | 4 | 1 |
| 249 | $22\frac{1}{2}$ | 2 |
| 251 | $8\frac{1}{2}$ | 2 |
| 260 | $5\frac{1}{2}$ | 1 |
| 263 | $6\frac{1}{2}$ | 0 |
| 267 | 5 | 7 |
| Total...................... | 167 | $82\frac{1}{2}$ |
| Mean amplitude per trial.... | .9 | .4 |
| $Sigma_{Mn}$................ | .12 | .06 |
| Median amplitude per trial.. | .8 | .3 |

## APPENDIX 17

*Response amplitude in mm.*

| RAT NO. | PRE-SHOCK GROUP DAYS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 4 | $26\frac{1}{2}$ | 28 | $5\frac{1}{2}$ | $18\frac{1}{2}$ | 27 | $26\frac{1}{2}$ | $13\frac{1}{2}$ | 24 | 13 | 35 |
| 20 | $35\frac{1}{2}$ | $30\frac{1}{2}$ | $33\frac{1}{2}$ | $22\frac{1}{2}$ | 37 | 43 | 28 | $37\frac{1}{2}$ | 38 | 22 |
| 45 | 28 | 17 | 12 | $12\frac{1}{2}$ | 10 | $24\frac{1}{2}$ | $20\frac{1}{2}$ | 29 | $26\frac{1}{2}$ | 26 |
| 54 | 56 | $45\frac{1}{2}$ | 46 | $47\frac{1}{2}$ | 38 | 37 | 27 | $38\frac{1}{2}$ | 34 | $47\frac{1}{2}$ |
| 76 | 56 | $40\frac{1}{2}$ | 33 | $44\frac{1}{2}$ | 26 | 41 | 27 | 38 | 29 | 43 |
| 99 | 46 | 38 | $35\frac{1}{2}$ | 26 | $32\frac{1}{2}$ | 29 | $34\frac{1}{2}$ | $17\frac{1}{2}$ | $24\frac{1}{2}$ | $28\frac{1}{2}$ |
| 134 | 30 | $29\frac{1}{2}$ | 20 | $12\frac{1}{2}$ | $22\frac{1}{2}$ | $27\frac{1}{2}$ | $25\frac{1}{2}$ | $23\frac{1}{2}$ | 28 | $30\frac{1}{2}$ |
| 142a | $23\frac{1}{2}$ | 28 | 22 | 30 | $31\frac{1}{2}$ | $23\frac{1}{2}$ | $29\frac{1}{2}$ | 21 | 27 | 24 |
| 157 | $26\frac{1}{2}$ | 19 | $30\frac{1}{2}$ | $19\frac{1}{2}$ | $17\frac{1}{2}$ | $23\frac{1}{2}$ | $22\frac{1}{2}$ | 32 | $20\frac{1}{2}$ | 22 |
| 197 | $32\frac{1}{2}$ | 26 | 33 | $38\frac{1}{2}$ | 33 | $31\frac{1}{2}$ | 20 | $31\frac{1}{2}$ | 40 | 30 |
| 200 | $30\frac{1}{2}$ | $19\frac{1}{2}$ | $29\frac{1}{2}$ | 33 | $40\frac{1}{2}$ | $35\frac{1}{2}$ | 46 | 48 | $44\frac{1}{2}$ | 31 |
| 209 | $28\frac{1}{2}$ | $18\frac{1}{2}$ | 22 | 29 | 28 | $29\frac{1}{2}$ | $31\frac{1}{2}$ | $18\frac{1}{2}$ | $21\frac{1}{2}$ | $36\frac{1}{2}$ |
| 229 | 21 | 19 | 36 | 40 | $30\frac{1}{2}$ | $23\frac{1}{2}$ | $31\frac{1}{2}$ | $25\frac{1}{2}$ | $28\frac{1}{2}$ | 29 |
| 248 | $26\frac{1}{2}$ | 26 | 18 | 25 | $29\frac{1}{2}$ | 20 | died | | | |
| 262 | $20\frac{1}{2}$ | 15 | $19\frac{1}{2}$ | $11\frac{1}{2}$ | 20 | $18\frac{1}{2}$ | $32\frac{1}{2}$ | $38\frac{1}{2}$ | 38 | 32 |
| 266 | 31 | $22\frac{1}{2}$ | $13\frac{1}{2}$ | 21 | $22\frac{1}{2}$ | 30 | 26 | $32\frac{1}{2}$ | 34 | 29 |
| Total....... | $518\frac{1}{2}$ | $422\frac{1}{2}$ | $409\frac{1}{2}$ | $431\frac{1}{2}$ | 446 | 464 | $415\frac{1}{2}$ | $455\frac{1}{2}$ | 447 | 466 |
| Mean....... | 32.4 | 26.4 | 25.5 | 27.0 | 27.8 | 29.0 | 27.7 | 30.3 | 29.8 | 31.0 |
| Sigma$_M$..... | 2.26 | 2.30 | 2.63 | 2.73 | 1.90 | 1.86 | 1.61 | 1.52 | 1.78 | 1.83 |
| Median..... | 29.9 | 26.0 | 27.5 | 26.6 | 28.7 | 27.5 | 27.9 | 29.1 | 28.5 | 30.6 |

## APPENDIX 18

*Response amplitude in mm.*

| RAT NO. | PRE-SHOCK GROUP TRIALS DURING FIRST EXTINCTION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 4 | 6 | 4 | 3 | 3 | 5 | 4 | 3 | 1 | 4 | 1 |
| 20 | $\frac{1}{2}$ | 6 | $3\frac{1}{2}$ | 6 | 3 | $2\frac{1}{2}$ | 0 | $\frac{1}{2}$ | 2 | 0 |
| 45 | 2 | $3\frac{1}{2}$ | 6 | $\frac{1}{2}$ | 0 | 2 | 0 | 0 | 2 | 0 |
| 54 | 7 | $5\frac{1}{2}$ | 4 | $5\frac{1}{2}$ | $6\frac{1}{2}$ | 5 | 3 | 5 | 3 | 5 |
| 76 | 7 | 4 | 3 | 4 | 3 | 3 | $1\frac{1}{2}$ | 3 | 4 | 2 |
| 99 | 3 | 6 | 3 | 5 | 3 | 4 | 2 | 2 | 2 | 4 |
| 134 | 4 | 6 | 4 | 4 | $3\frac{1}{2}$ | $4\frac{1}{2}$ | 3 | 3 | 3 | 3 |
| 142 | 5 | 4 | 5 | $3\frac{1}{2}$ | $3\frac{1}{2}$ | 3 | 2 | 2 | 4 | 4 |
| 157 | $3\frac{1}{2}$ | 4 | 4 | 3 | $2\frac{1}{2}$ | 2 | $2\frac{1}{2}$ | 0 | 0 | $\frac{1}{2}$ |
| 197 | 1 | 2 | $4\frac{1}{2}$ | $\frac{1}{2}$ | $1\frac{1}{2}$ | 5 | 3 | 1 | $2\frac{1}{2}$ | 4 |
| 200 | 4 | 8 | 8 | 4 | 6 | 2 | 6 | 5 | 4 | 0 |
| 209 | 3 | $4\frac{1}{2}$ | 6 | $4\frac{1}{2}$ | 3 | 4 | $3\frac{1}{2}$ | 5 | 2 | $3\frac{1}{2}$ |
| 229 | 4 | 4 | $3\frac{1}{2}$ | $4\frac{1}{2}$ | 2 | 3 | $2\frac{1}{2}$ | 2 | 3 | 4 |
| 262 | 4 | 3 | 2 | 4 | 5 | 2 | 4 | 2 | $1\frac{1}{2}$ | $2\frac{1}{2}$ |
| 266 | 7 | 3 | 6 | $4\frac{1}{2}$ | 0 | 0 | 3 | $1\frac{1}{2}$ | $\frac{1}{2}$ | 0 |
| Total | 61 | $67\frac{1}{2}$ | $65\frac{1}{2}$ | $56\frac{1}{2}$ | $47\frac{1}{2}$ | 46 | 39 | 33 | $37\frac{1}{2}$ | $33\frac{1}{2}$ |
| Mean | 4.0 | 4.4 | 4.3 | 3.7 | 3.1 | 3.0 | 2.6 | 2.2 | 2.4 | 2.1 |
| Sigma$_M$ | .52 | .39 | .41 | .41 | .47 | .34 | .38 | .44 | .34 | .46 |
| Median | 4.4 | 4.6 | 4.3 | 4.3 | 3.4 | 3.5 | 3.0 | 2.4 | 2.9 | 2.7 |

## APPENDIX 19

*Pre-shock group*
*Extinction trials, second and third series*

| RAT NO. | TIME AFTER FIRST EXTINCTION SERIES | |
| --- | --- | --- |
| | 24 hrs. | 48 hrs. |
| 4 | 45 | 20 |
| 20 | 27 | 10 |
| 45 | 24 | $16\frac{1}{2}$ |
| 54 | 25 | $27\frac{1}{2}$ |
| 76 | 25 | 28 |
| 99 | 30 | 13 |
| 134 | 30 | 24 |
| 142 | 28 | 16 |
| 157 | 15 | 19 |
| 197 | $25\frac{1}{2}$ | 17 |
| 200 | $28\frac{1}{2}$ | $18\frac{1}{2}$ |
| 209 | 18 | 8 |
| 229 | $19\frac{1}{2}$ | 3 |
| 262 | 24 | $21\frac{1}{2}$ |
| 266 | 13 | 11 |
| Total..................... | $377\frac{1}{2}$ | 253 |
| Mean amplitude per trial .... | 2.5 | 1.7 |
| Sigma$_{Mn}$................ | .20 | .15 |
| Median amplitude per trial.. | 2.5 | 1.7 |

## APPENDIX 20

*Total amplitude of response during one day of conditioning*

PSEUDO-CONDITIONING GROUPS
DAYS OF SHOCK TRAINING PRECEDING ONE DAY OF CONDITIONING

| 0 | | 1 | | 2 | | 3 | | 5 | | 7 | | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rat No. | Response | Rat No. | Response | Rat No. | Response | Rat No. | Response | Rat No. | Response | Rat No. | Response | Rat No. | Response |
| 1 | 14 | 238 | 31½ | 32 | 21½ | 59 | 39½ | 126 | 39 | 2 | 28 | 4 | 26½ |
| 26 | 5½ | 283 | 33½ | 36 | 19½ | 113 | 42½ | 170 | 23½ | 62 | 26½ | 20 | 35½ |
| 50 | 34½ | 288 | 64 | 41 | 33 | 236 | 32 | 255 | 16½ | 243 | 36½ | 45 | 28 |
| 52 | 35½ | 313 | 31 | 135 | 21½ | 240 | 20½ | 300 | 26½ | 301 | 38 | 54 | 56 |
| 60 | 15 | 315 | 29½ | 317 | 32½ | 306 | 15 | 305 | 18½ | 302 | 16 | 76 | 56 |
| 79 | 9 | 316 | 30 | 318 | 16 | 308 | 23½ | 311 | 41 | 303 | 29 | 99 | 46 |
| 116 | 14 | 322 | 22 | 319 | 20½ | 309 | 24 | 312 | 19 | 304 | 20½ | 134 | 30 |
| 143 | 22 | 330 | 34 | 338 | 37½ | 310 | 14 | 314 | 15½ | 307 | 16 | 142a | 23½ |
| 149 | 8½ | 331 | 38 | 339 | 26½ | 325 | 22 | 321 | 26 | 320 | 25½ | 157 | 26½ |
| 155 | 13 | 332 | 28½ | 340 | 28 | 326 | 43 | 324 | 32 | 323 | 27½ | 197 | 32½ |
| 174 | 18½ | 333 | 25 | 341 | 20½ | 327 | 15½ | | | | | 200 | 30½ |
| 177 | 10 | 334 | 28½ | 342 | 26½ | 328 | 18½ | | | | | 209 | 28½ |
| 183 | 38½ | 335 | 22½ | 343 | 25 | 329 | 24½ | | | | | 229 | 21 |
| 188 | 14 | 336 | 19 | 344 | 18 | | | | | | | 248 | 26½ |
| 194 | 9½ | 337 | 28½ | | | | | | | | | 262 | 20½ |
| 196 | 35 | | | | | | | | | | | 266 | 31 |
| 204 | 6½ | | | | | | | | | | | | |
| 214 | 35½ | | | | | | | | | | | | |
| 220 | 15 | | | | | | | | | | | | |
| 227 | 8½ | | | | | | | | | | | | |
| 246 | 8½ | | | | | | | | | | | | |
| 259 | 16½ | | | | | | | | | | | | |
| 264 | 24½ | | | | | | | | | | | | |
| 268 | 28 | | | | | | | | | | | | |
| Total... | 439½ | | 465½ | | 346½ | | 334½ | | 257½ | | 263½ | | 518½ |
| Mn..... | 17.6 | | 31.0 | | 24.7 | | 25.7 | | 25.7 | | 26.3 | | 32.4 |
| $Sigma_{Mn}$ | 2.19 | | 2.56 | | 1.57 | | 2.91 | | 3.33 | | 1.97 | | 2.26 |
| Md..... | 14.9 | | 29.5 | | 24.9 | | 22.5 | | 23.3 | | 27.0 | | 29.9 |

# COMPARATIVE PSYCHOLOGY MONOGRAPHS

## DATE DUE

DEMCO 38-297